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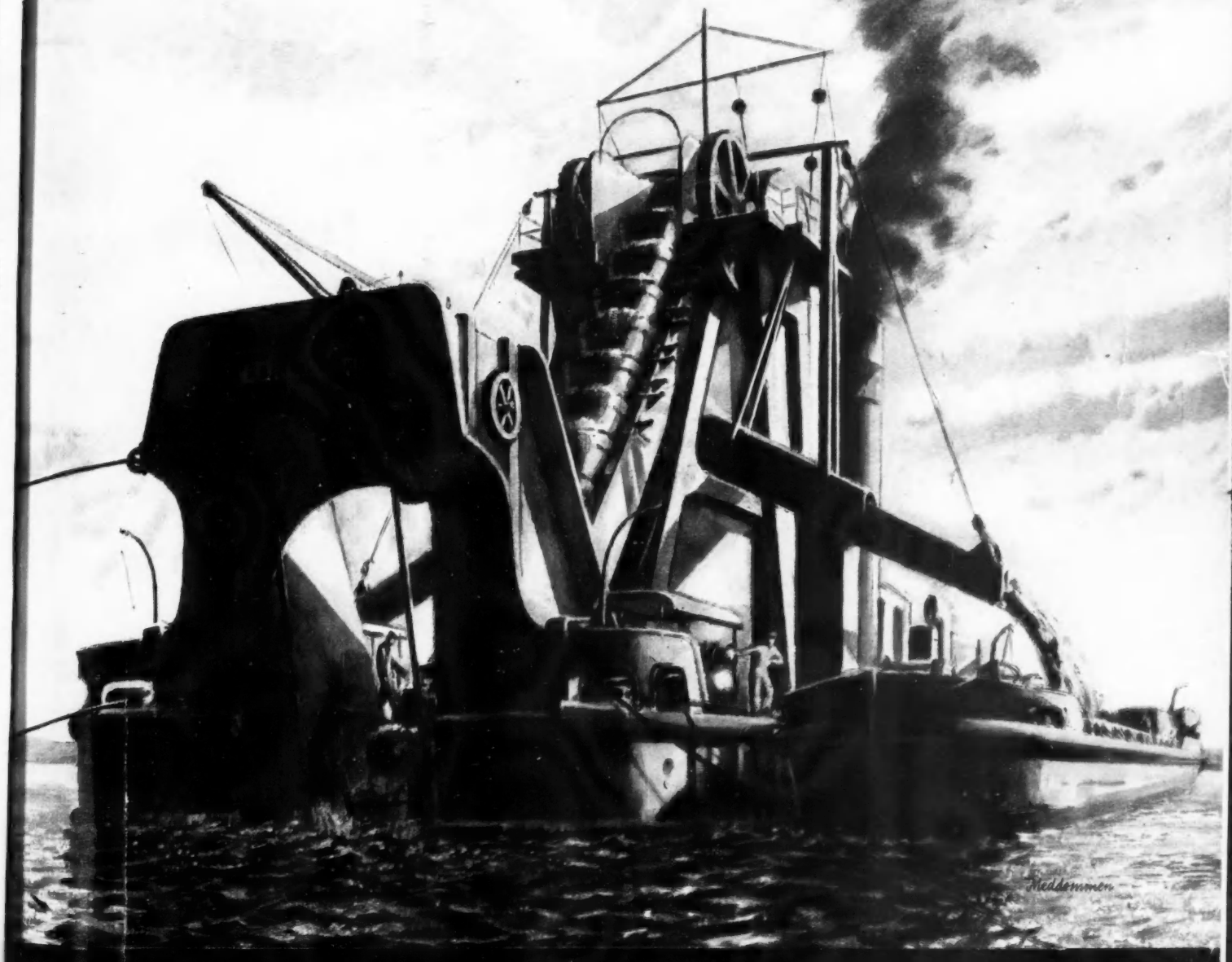

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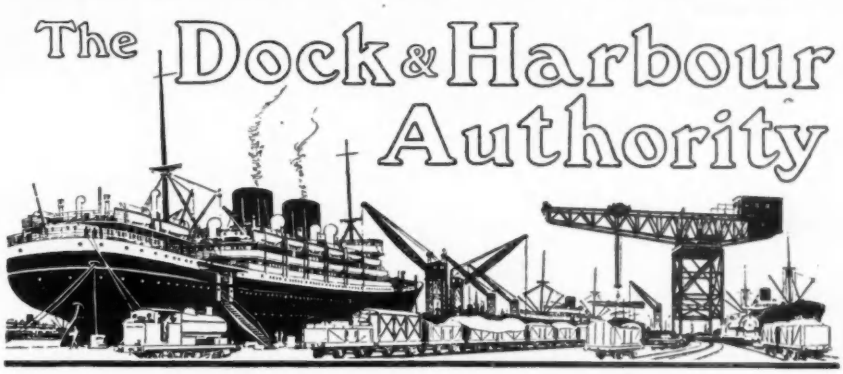

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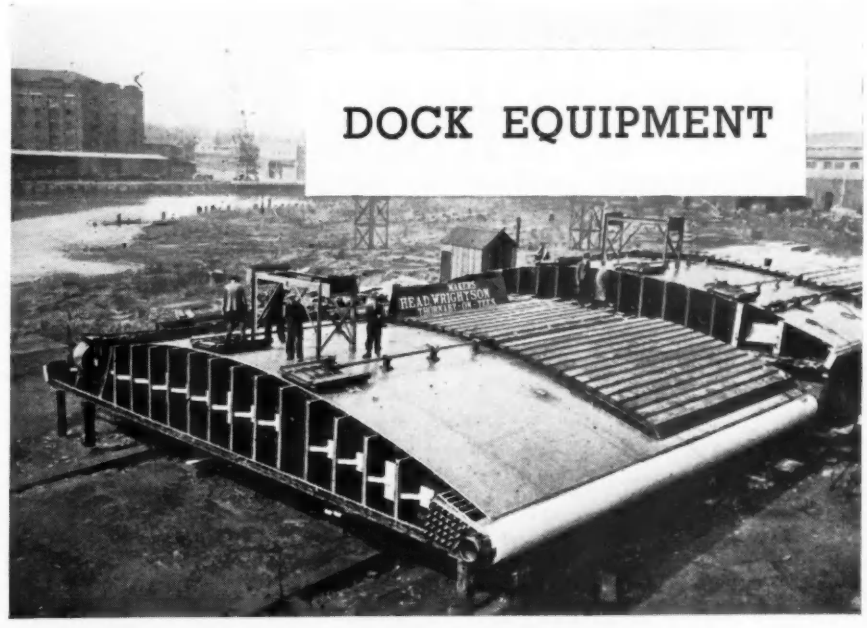

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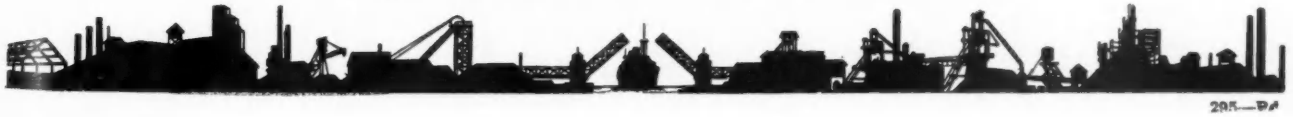

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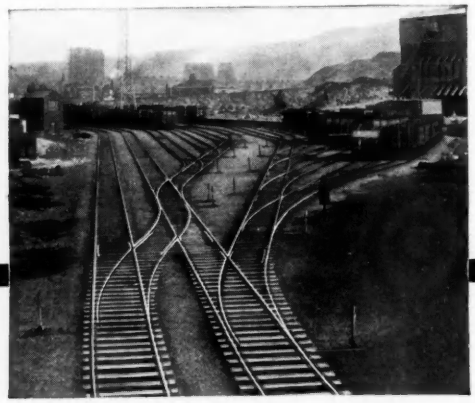

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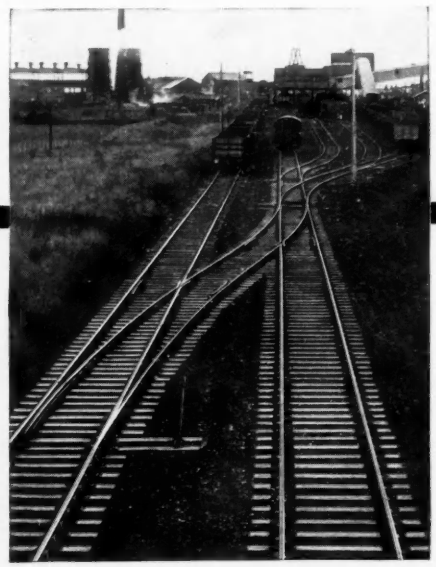

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Editorial Comments

Two-Storey Transit Sheds.

During recent years much has been written about the relative merits of single, two-storey and multi-storey dock transit sheds. The reason for this interest is largely because of the increase in the size of modern cargo vessels and the necessity for providing more space ashore for the expeditious handling of larger quantities of import and export cargo.

In this issue we are publishing an article, by Ing. Helmut Jung of the Port of Bremen, which has been compiled from data collected during the course of investigations into the merits of the two-storey shed. With characteristic thoroughness the varying aspects and divergent opinions regarding transit sheds at a number of world ports are analysed and commented upon.

For obvious reasons, the transit shed should not be of greater length along the quay than the length of the ship's berth which it serves. There are therefore only two directions in which extra accommodation can be obtained—by making the shed wider or higher. There is usually, however, a limit to the increase in width. The cost of handling goods over a wider area must also be taken into consideration, although if mechanical handling equipment of the right type is available, the additional cost may be insignificant.

The view that it is uneconomical to raise merchandise to an upper floor in a transit shed, and then to lower it again is not necessarily true; as our contributor has pointed out, there are a number of factors which must be considered. We might, however, emphasise certain further advantages that may arise from the use of two-storey sheds. Import and export cargoes can be completely separated, so that the collection of general cargo for export can be spread over several days prior to the sailing of a ship, instead of a part of it arriving at the time of the ship's departure. By this means congestion of transport and long hours of waiting, due to the concentration of lorries and trains dealing with exports as well as imports, may be wholly avoided or largely reduced. Moreover, with two floors to a shed, the loading of any hold of a ship can be proceeded with as soon as the import cargo has been cleared from it, without any interference between loading and unloading operations.

The author, in his summing up, gives some convincing arguments for his contention that the two-storey transit-shed deserves the most careful consideration in port reconstruction schemes. This conclusion appears to have found favour in many ports throughout the world.

Dock Labour Scheme Inquiry.

The first sitting of the Committee of Inquiry into the working of the Dock Labour Scheme was held in London on October 18th, under the chairmanship of Mr. Justice Devlin. Further meetings will be taken up with examination of statements submitted to the Committee by organisations of employers, workers in the industry and other interested parties.

It is to be emphasised that this Inquiry does not have as part of its terms of reference an examination of conditions in the dock industry in general; the purpose of the Committee is to examine to what extent the Dock Labour Scheme is operating satisfactorily, and if necessary to recommend measures which will bring its workings up to date.

The Dock Labour Scheme has now had ten years in which to prove itself. Since the scheme and its administration are now under close examination it would be out of place to comment on a matter which must be for the present regarded as sub-judice. The main features of the situation may however be briefly outlined.

Since the scheme was inaugurated ten years ago, the status and general working conditions of the dockers has been greatly improved; no one who has social progress in its widest sense at heart could wish to see the clock put back. At the same time there are many complaints from shipowners that their very real efforts to cut transport costs by saving time at sea are often nullified by time wasted in port. Although it can be shown in many instances that slow turn-round of ships in port can be attributed to disappointing output on the part of dockers, that is not to say that the blame for this necessarily falls on either the scheme or upon the National Dock Labour Board. It may or it may not; alternatively the fault may be found to lie not in the administration of the scheme but simply in human nature. In this connection it is interesting to note that the Melbourne Harbour Trust Commissioners, in their Report for 1954, state that despite considerable increases in port amenities, mechanical handling devices and wharf cranes in service, the tonnage of cargo handled across the wharves in a day is now only about half that which was handled in 1937 and 1938.

One criticism of the Dock Labour Board has been levelled by a disinterested observer, the Department of Social Science, Liverpool University, who have recently concluded a survey of labour in the Port of Manchester (a review of which was published in the July issue of this Journal). It is that the creation of the National Dock Labour Board has led to the existence of a nebulous type of employer. As Lord Waverley has put it, the normal employer-worker relationship has become blurred. It may be that there is much to be said for this point of view, which has its parallels in nationalised industry where it has been evident for some time that the best work is not secured from men who do not know who the boss is. An examination of this aspects of the scheme would appear to be within the terms of reference of the enquiry, and it will be interesting to see what the Committee make of it. Should this line of approach turn out to be fruitless the enquiry must in the national interest be pursued into realms which are perhaps outside the Committee's ambit.

One comment might perhaps be made in view of the foregoing; it is that perhaps it is to be deplored that the Committee of Inquiry has been set up with a narrow objective. The Committee's findings as and when they appear may satisfy or instruct the Ministry of Labour, which requested the Inquiry, but it is by no means certain that the Committee are in a position to make searching examination of the root causes of dock delays. The solution of this problem is vital to all who have a healthy shipping industry and indeed the welfare of the nation at heart.

Editorial Comments—continued

Ship Fire Prevention in Port.

A new notice was issued by the Ministry of Transport and Civil Aviation in October last on fire prevention and fire fighting in port. This notice (No. M. 393) is for the guidance of shipowners, shipmasters, shipbuilders and repairers, and it may be deemed to arise largely from a consideration of the facts elicited at the court of inquiry into the loss of the "Empress of Canada" in Liverpool in 1953. It emerged at that inquiry that many of the recommendations which had been made by the Working Party on Fire Prevention and Fire Fighting in ships in Port, published in 1950, had not been carried out.

It is not proposed to make extensive quotations from the recently published notice. There are however one or two points which would appear to be of vital interest to harbour authorities, notwithstanding the fixing of legal responsibility on other parties. In the event of a ship catching fire and sinking in a dock or harbour the fact that the blame may be laid at someone else's door is little consolation to the port authority when a hulk which may take months to raise is blocking the fairway or occupying valuable quayside space. In other words the port authority itself has a vital interest in both the prevention of fire in ships, and in the conduct of the fire fighting if a fire breaks out. In this connection the notice re-affirms that "the responsibility for fire prevention and fire fighting in ships under construction is the builder's responsibility, and in ships under repair the owner's responsibility, unless in either case there is a written agreement to the contrary."

On the subject of ships' fire-fighting appliances the notice states that "at all times water supplies of adequate pressure should be immediately available on board ship, either in the ship's fire main or in hoses run aboard by the local fire services. Extra apparatus such as adaptors for hose couplings, boosters, pumps, etc., should always be available, and the provision of any additional apparatus considered necessary for the particular ship should not be left until there is an outbreak of fire. Any fire appliances removed for repair or recharging should be replaced at once with a like number of similar units."

The responsibility of the harbour authority in seeing that facilities are constantly available, and that rapid access to the ship under repair is at all times feasible is not clearly defined, yet it would appear that in this respect the harbour authority is in a position which lays a considerable burden on itself, both in discharging its liabilities to the shipowner and as a matter of self interest. The harbour authority is further placed in an unenviable position by the contents of the section on Stability which states that "when fire fighting operations endanger a ship's stability and it is necessary to decide whether fire fighting operations should cease, the decision of the Harbour Master or other responsible officer of the Port Authority, after consultation with all interested parties should prevail. This recommendation puts the Harbour Master in a quandary, where he may have to decide that the capsizing of a ship is preferable to the ignition of his harbour installations.

The Notice finishes on a strong note: "Conclusions such as these may seem to be obvious and elementary. This is by no means the view of the Working Party. The failure to observe the simplest precautions is undoubtedly responsible for many incidents, involving cost to the nation which cannot be measured in terms of money and materials alone; it is for this reason that we stress in our conclusion that only by constant vigilance can the risk of fires in ships in port be minimised."

New Fire Fighting System.

The two outstanding disasters of recent years involving big ships have been the "Normandie" in New York and the "Empress of Canada" mentioned above. In each case the ship capsized owing to loss of stability, caused by the immense weight of water injected into the hull. It is therefore of special interest to see that a new system of fire fighting is now under development by the Pyrene Company, whereby unlimited quantities of inert gas can be generated and discharged into the spaces where the fire is to be fought. Briefly the system comprises a combustion chamber and blower, through which air is passed; the burning of diesel oil fuel serves to strip the atmospheric air of at least 99 per cent. of its oxygen, and the resultant mixture of carbon dioxide and nitrogen is, after cooling, blown into the spaces wherein the fire is to be fought, thus surrounding the inflammable goods with an oxygen free environment. The volume of gas which can be generated by this means is limited only by the supply of diesel oil.

The system is only in its infancy, and is first to be applied to the holds of a ship now under construction at Belfast. Looking ahead, however, there would appear to be a future for this device, both in the protection of sheds and warehouses (be it noted that a hold or warehouse adjacent to an existing fire can be given a precautionary dose of inert gas without spoiling the contents), and for quelling outbreaks of fire in ships in port. It may in fact not be too visionary to conceive of docks in which a ring main for the supply of inert gas connected to a central gas generator may become an alternative or even a substitute for the existing ring main of water for fire fighting.

Comparative Transport Costs

Institute of Transport Presidential Address

Mr. Peter G. Masefield, retiring Chief Executive of British European Airways has recently provided a masterly survey of the relative costs of differing types of transport, in his Presidential Address, delivered on 10th October last, to the 1955-6 Session of the Institute of Transport in London.

The main theme of the address was sea and air competition; in the course of Mr. Masefield's exposition some very interesting facts emerged as to the relative costs of inland waterway and sea-borne traffic. Mr. Masefield said that compared with their hey-day in the 18th century, when immense profits were made on the sale of canal shares, the inland waterways to-day presented a sad picture.

During 1954-1955, 225,000,000 load ton miles of traffic were performed on inland waterways in Great Britain. Of this amount 49,000,000 L.T.M. were recorded on the British Transport Commission vessels, which earned a revenue of about £1 million. In all 4,050 barges travelled some 8 million miles, achieving a load factor of 54 per cent. at an average speed of 5.5 miles an hour. Costs were on average 2.7 pence a capacity ton mile—nearly double those of railways and 18 times those of sea transport, chiefly because of the small capacity of the canal boat. The high cost and slow speed of the inland waterways was a disappointing feature.

Mr. Masefield went on to say "Traditionally and economically, in our great seafaring nation, by far the largest single component in British transport is shipping. The British mercantile marine is still, in fact, the largest on the world's seas by a substantial margin. British shipping, indeed, earns some 44 per cent. of the total revenue of British Transport as a whole, while it carries some 94 per cent. of the traffic—amounting to some 716,000 million load ton miles—the transport unit of earning power. These loads were carried in about 3,200 vessels which, during 1954, steamed 102 million ship miles at an average speed of some 13 knots.

"One of the economic advantages to be gained from use of large vehicles is brought out in the shipping figures. While carrying 94 per cent. of the traffic, shipping employs only 23 per cent. of the total manpower in British Transport. The mean operating cost for the shipping industry as a whole works out at only one-seventh of a penny for each capacity-ton-mile worked, and is substantially the lowest of any means of transport. It is, in fact, half the mean rate for all forms of transport. In other words, bulk transport by sea in large vessels, is the cheapest way of carrying goods over longer distances at relatively slow speeds. The cost of conveying passengers by sea, is however, a great deal higher—passenger fares ranging in fact between about fourpence and ninepence a passenger mile, figures which are at the same level as those of air transport."

British shipping appeared to achieve a fair surplus of revenue over operating costs—a margin of at least 11 per cent., which amounted to about £80 million per annum. This was achieved at the low average revenue rate of only one farthing for each load ton mile sold. At the rates and costs prevailing, the average ship must fill 52 out of every 100 tons available for load, if she was to begin to make profits.

Two-storey Transit Sheds at Seaports

A Review of Existing Designs

By Oberbaurat Dipl. Ing. HELMUT JUNG, Bremen.

Introduction.

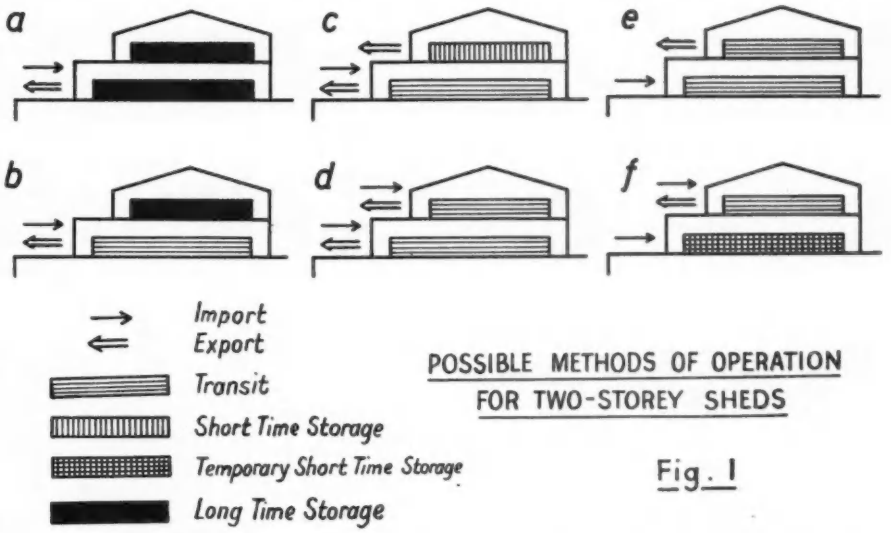
IN connection with the task of designing No. 6 Transit Shed, with a length of 300 metres, for Bremen's "Europe Dock," the more than thirty years old question of the merits of two-storey transit sheds for general cargo was re-examined in the light of new view-points that have meanwhile been developed.

Method of Operation in Two-Storey Transit Sheds.

Widely differing opinions are expressed on the subject of two-storey transit sheds at seaports, ranging from downright rejection, at the one extreme, to the view that the two-storey shed represents the economical solution of the future for the problem of the transit shed. the intermediate view being that the two-storey shed has its advantages in certain circumstances.

Before stating the different opinions on the value of two-storey sheds, it would first appear desirable to give a brief description of the different methods of operating sheds of this type.

The numerous possibilities of operation presented by them can, in the main, be grouped under a small number of systems, which are represented diagrammatically in Fig. 1 and will now be briefly explained. Strictly speaking, the method of operation shown in Fig. 1a is not that of a quayside transit shed. Both floors serve only for the long-term storage of goods in the immediate vicinity of deep-water berthing accommodation. The purpose of an arrangement of this kind is to be able to load the vessel directly from, or to discharge its cargo directly into, the store building, in the case of goods destined for a long period of storage, with a view to saving the extra cost that would otherwise be entailed by first passing the goods through a transit shed as an intermediate place of storage. Such a system of quayside warehouses is rarely encountered, but has, for example, been employed for the tobacco warehouses at the Gladstone Docks at Liverpool; in this instance, and also in other cases, as for example at Stettin, these are multi-storey buildings.



POSSIBLE METHODS OF OPERATION FOR TWO-STOREY SHEDS

Fig. 1

Generally, however, multi-storey store buildings are so operated that the ground floor is meant for the "through" traffic of transit goods and also serves for the sorting of goods that are to be stored on the upper floors of the warehouse. In the case of a two-storey shed this method of operation is illustrated in Fig. 1b, where the upper floor is used for long-term storage, whereas the ground floor is used for the handling of import and export goods in transit.

In both of the above-mentioned methods of operation (1a and 1b) direct intercourse between the ship and the upper floor of the shed is only very limited. Vertical transport of goods is for the most part effected inside the building with the aid of lifts, i.e. nearly all goods travel by way of the ground floor.

The method of operation illustrated in Fig. 1c is more frequently met with. Transit goods are handled on the ground floor, the upper floor being reserved for short-term storage. This system is usually employed in the case of sheds operated in conjunction with a regular steamer service. Thus goods for export may be stored in readiness on the upper floor during the intervals between sailings and, after the ship has discharged its cargo into the ground floor of the shed, the goods can be directly put on board, thereby avoiding the cost of transporting them from a distant intermediate warehouse.

Fig. 1d shows a method of operation which is not often applied in practice but which, on account of its somewhat disorderly character, is frequently produced as an argument against the two-storey shed, viz. indiscriminate movement of goods through the shed on both floors without maintaining any distinction between the two directions of movement.

Congestion may arise in single-storey sheds because imported goods have to be conveyed past goods awaiting export and stored, or vice versa. This has led to the view that the two-storey shed possesses a special advantage in that the upper floor can be used exclusively for imports and the ground floor exclusively for exports, or conversely. This method of operation gives good results provided it can be so arranged that the importing vessel can, while remaining at the same berth, take in its cargo for export from the upper floor of the shed, i.e. when worked in conjunction with regular steamer services run by shipping companies.

Finally, there is a method of operating the two-storey shed which, as appears from an examination of the various view-points put forward, meets with the least opposition, viz. the combination of a transit shed for general cargo with a shed for fruit, as the latter will be used for the seasonal trade in fruit only during a certain part of the year and will for the remaining time be available for general cargo purposes, thus promoting economical operation of the installation.

The two-storey shed is now considered the obvious choice for dealing with passenger traffic and as such will not be discussed here, even though passengers may be regarded as "top-grade general cargo."

The above-mentioned basic methods of operating a two-storey shed—there are, in addition, a great many possible variants—are, of course, judged very differently by different Harbour Boards, according to the point of view adopted. These various views may be summarised as follows:—

(a) Every port has its own individual character in respect of the goods that determine its particular trade and therefore has its own rules of operation. Export harbours operate differently from import harbours; ports specialising in, for example, the cotton trade, have methods of operation differing from those of general cargo ports, and these latter vary according as the bulk of the goods traffic to and from the port is handled by rail, by lorry or by barge.

Two-storey Transit Sheds at Seaports—continued

(b) Nearly every port has a different form of organisation for the management of the port activities as a whole. According as this management is in the hands of a Port Authority, a private company or a semi-private corporate body, different methods of management will apply.

(c) Every Harbour Board holds different views on the efficient use of the separate installations as well as of the port facilities as a whole.

(d) At almost every port the shippers of goods hold different views on the usefulness of this or that installation, or of this or that system of operation, and assert their influence accordingly.

(e) Traditional habits, which can only be changed gradually and to a limited extent, very often play a decisive part with regard to the selecting or maintaining of a certain method of operation of the port facilities.

For the above reasons it is obvious that a technical installation such as the two-storey shed will be judged differently by the authoritative circles controlling the construction and operation thereof, although many buildings of this kind have already been constructed in accordance with certain general basic principles with regard to the design of the two storeys, the handling of cargo on the water side with the aid of quay cranes, the arrangements for the vertical transport of goods by means of lifts, etc., and differ only in matters of detail.

Divergent Opinions.

Here follows a selection of different characteristic opinions that have, during the past thirty years, been expressed in the voluminous literature on the question whether two-storey or single-storey transit sheds are preferable.

It should be mentioned that appreciably greater prominence appears to be given to this subject in German than in foreign technical literature.

This controversy was really started by the construction of the shed-warehouse at Stettin—which in the nineteen-twenties radically broke with the established tradition of the single-storey transit shed in German seaports—and has not subsided since.

The plans for the post-war reconstruction of the seaports have revived the controversy.

Here are some opinions:

De Thierry (Berlin) (" Requirements of modern cargo-handling in port construction," in the special number " Güterumschlag " of the Journal of the Association of German Engineers, V.D.I., 1925, page 108 et seq.) notes the rejection of multi-storey sheds by the German seaports and points out that in other countries two-storey sheds are being built in considerable numbers and calls attention to the positive results obtained in operating the warehouse at Stettin.

Tillmann (Bremen) (discussion on the above paper) is of the opinion that the examples of multi-storey sheds in Britain, Holland and Sweden are indeed suitable for the conditions of operation obtaining there, but that such sheds are necessitated by space restrictions in the ports concerned and are less convenient and less economical to operate than single-storey sheds.

Foerster (" The Berlin West Port," in the above-mentioned special number of " Güterumschlag," page 143 et seq.) considered two-storey sheds a perfectly economic proposition. The only grounds for justified criticism of the two-storey shed at the Berlin West Port are faulty design with regard to facilities for vertical transport, the absence of verandahs on the upper floor, inadequate load-carrying capacity. etc.

Krüger (Bremen) (in the above-mentioned special number, page 147 et seq.) fears difficulties in the handling and storage of goods in a two-storey building and, consequently, increased operative costs; finally, he states that the treatment of cotton (a commodity of prime importance to Bremen at the time) calls for good natural lighting, which can be satisfactorily achieved only in a single-storey shed.

Brockmann (Year Book of the Association for Harbour Construction, Vol. 9, 1926, page 194 et seq.) has conducted exhaustive economic researches on the use of two-storey sheds at the port of Hamburg. His treatise concludes with the recommendation not to go in for two-storey sheds, because—as he asserts—if the upper floor is employed for storage purposes this will interfere with the rapid handling of transit goods on the ground floor; and if both floors are used for transit operation, the intended better utilisation of the quays by the steamer will not be achieved, as a higher percentage of the goods will then be conveyed away from the water side of the shed in barges, with the result that the latter craft will cause increased congestion at the quays.

If the trans-shipment of goods, which is characteristic of transit cargo handling at Hamburg (warehouse, barge, shed, steamer, or vice versa), could be dispensed with, i.e. by transporting goods mainly by rail or by lorry, then Brockmann sees definite possibilities of also using two-storey sheds in order to increase the volume of goods handled per linear metre of quay.

Van Hiemskerk van Beest (" Two-storey Sheds at the Port of Amsterdam," Year Book of the Association for Harbour Construction, Vol. 10, 1927, page 164 et seq.) considers the two-storey arrangement to be advantageous in cases where the depth of the shed (which is determined by the volume of cargo to be dealt with) and the requisite alley-ways become too large. At Amsterdam, moreover, the limited amount of space available was of decisive importance.

The central theme at the main meeting of the Association for Harbour Construction (" Hafenbautechnische Gesellschaft "), in 1930, was: " Single- or multi-storey quayside sheds and dock warehouses considered from the operating and economic point of view, and the consideration of quayside transit cargo-handling in relation to warehouse storage " (Year Book of the Association for Harbour Construction, Vol. 12, 1930/1931, page 15 et seq.). The following summaries have been taken from the mass of contributions on the subject:

Sieveking (Hamburg): The question of the most suitable type to adopt, whether single- or two-storey, cannot be decided by considering the shed alone, but must be viewed in connection with **the port facilities as a whole.** Smooth handling of transit cargoes calls for a certain shed area; the provision of this area must take priority over the question whether the shed should be of single- or two-storey design. Sieveking considers the advantages of the two-storey shed to consist in the smaller amount of building space required, in the shorter distances over which the goods have to be moved, in its suitability for special purposes such as passenger traffic, etc. Against this, the disadvantages are the increased cost of the foundations, the higher cost of construction per square metre of storage area, the cost of equipment for vertical transport, the encumbrance due to the presence of columns and the poor daylighting conditions on the ground floor, and finally the limited load-carrying capacity of the upper floor. Sieveking's paper gave rise to the following discussion:

Dronke (Bremen) rejects two-storey sheds, except for very special cases; he estimates the operating costs to be over 40 per cent. higher than those for a single-storey shed.

Buschmeyer (Hamburg) considers the simultaneous unloading of cargo into two storeys of a shed to be virtually an impossibility and regards the two-storey shed as a mere legend.

Tillmann (Bremen) considers the two-storey shed acceptable only in cases where there is an acute lack of space. He states that at Bremen the construction of such sheds was definitely rejected because they tended greatly to reduce the general convenience of operation.

Koomans (Rotterdam) refers to the two-storey structures of two large shipping companies at Rotterdam, which buildings have proved perfectly satisfactory and have led to the construction of further buildings of similar type.

De Thierry (Berlin) summarised the paper and the discussion in the statement that the question of the single-storey or two-storey shed cannot be judged in general terms but only in relation to local conditions at the various ports concerned; he considers that the significant points are whether a port is a transit port or a terminal port, whether the inland transport of goods is effected by rail or by barge, and what goods determine the character of the handling operations.

Two-storey Transit Sheds at Seaports—continued

Loos (Year Book of the Association for Harbour Construction, Vol. 12. 1930/1931, page 34 et seq.) reports that in the Netherlands Indies ports single-storey sheds were pulled down and replaced by two-storey sheds with a view to using the upper floor as a collecting warehouse for export goods delivered at the port during the intervals between sailings.

Bénézit (Ports et Travaux Maritimes, Paris 1931, page 22) comes to the conclusion that transit cargo-handling on two storeys is not much more expensive than in a single-storey shed and that in certain circumstances vertical transport is even more economical than having to move goods a longer distance horizontally.

Jansson and Semler ("The constructional development of the Swedish ports after the World War," Year Book of the Association for Harbour Construction, Vol. 17, 1938, page 262 et seq.) comment on the various types of sheds—of single, two-, or mutli-storey construction—in Swedish ports, with reference to the amount of available space in each case, which is a more important consideration than economy of operation. (The numerous different forms of multi-storey sheds and warehouses is at the present time still a striking feature of Swedish ports.)

The development of reconstruction schemes for the German seaports, necessitated by the heavy damage they suffered during the war, has revived the controversy on the question whether single-storey or two-storey sheds should be adopted:

Mühlradt (Hamburg) (German Reports for the 18th International Shipping Congress 1953, page 218 et seq.) states that Hamburg is going to build single-storey sheds, as discharging and loading operations carried out on two floors would entail an increase in costs of at least 25 per cent.

Agatz (Bremen) ("Latest quay development for the handling of general cargo at seaports," Hansa 1953, page 1475 et seq.) publishes a cross-section of the 50 metres wide two-storey sheds incorporated in his plans for the extension of the port of Bangkok. In these sheds the ground floor is meant for dealing with imports, while the upper floor, with a width of 40 metres and connected by means of bridges to warehouses in the rear, is intended for export cargoes.

Sheds of a very similar type, likewise connected by bridges to warehouses in the rear, were adopted in the design for the port of Kandla (India) and were recommended by Agatz.

De Kezel (International Shipping Congress 1953, Report SII-C$_2$, page 37) sees disadvantages in the two-storey shed from the point of view of general port operation, but considers it a serviceable solution if the lower and upper floor are under one and the same operating management, as is, for example, the case with the Gare Maritime de Compagnie Maritime Belge at the Leopold Dock at Antwerp.

The above summary of different views on the construction and operation of two-storey sheds outlines their advantages and disadvantages and the limits of their applicability; it thus provides some guidance on the questions that must necessarily be considered in designing a structure of this kind.

Technical Data on various new Shed Structures.

In view of the existing differences in opinion, it stood to reason that, in preparing the designs for No. 6 Shed at Bremen, particular attention was paid to buildings which had at the time been projecetd or had already been erected at other ports. These investigations were deliberately confined to structures which had been built since the last war.

The very considerable changes that are to be noted in comparison with the pre-war period are not merely confined to:

(a) constructional methods, in which the increased use of prestressed concrete, precast concrete units, higher-strength steels, etc. have created new structural possibilities. Of the considerable progress achieved in other branches of engineering, suffice it to mention by way of example the use of fluorescent lighting, which has greatly simplified the serious problem of illumination.

(b) It had also to be taken into account that the part played by the motor lorry in the total volume of traffic, with its increased requirement of road space, must be duly allowed for in planning the port.

(c) Finally, conditions of cargo-handling at ports have altered considerably with regard to the proportion of cargo dealt with in the transit sheds (" through " goods) and in the warehouses (long-term storage). The need for effecting the speediest possible completion of a transaction between the producer and the final consumer, in conjunction with the desire to achieve the smoothest possible flow of goods in order to cut down interest losses, storage expenses, etc., has caused higher demands to be made upon sheds at ports. The trend is to obtain the greatest possible area of shed for short-term storage accommodation per unit length of quay, whereas long-term storage in warehouses has declined in importance.

Details on a number of sheds have been published in the relevant technical literature. The data given in these publications, and partly supplemented by notes made in the course of study-tours, are summarised in the appended Table (see Fig. 2). The characteristic shed cross-sections are shown in Figs. 3—14.

As the structural features of the buildings were in many cases not adequately described in the publications concerned, the technical data given are not quite complete, but will nevertheless suffice to give a survey of the development of this type of building.

Evaluating the information contained in the above Table, we find that:

The two-storey shed is not a mere special feature of certain smaller or larger groups of ports in certain countries, but is built all over the world, and considerable interest is being focussed on it in connection with extension schemes for existing ports in endeavouring to achieve the maximum cargo-handling capacity in the available space.

Two-storey sheds may stand as separate structures side by side with single-storey sheds (Antwerp, Rotterdam, Bremen) or in rows along a whole length of quay (Dakar, Piraeus, Bangkok, Kandla).

The lengths of the buildings range from 65 metres (Dakar) to 300 metres (Bremen, Bangkok); at the two last-mentioned ports the sheds are subdivided by fireproof walls into sections of 100 and 150-metre lengths respectively,

The widths of the sheds range from 23.3 metres (Dieppe) to 58 metres (Antwerp), approximately 40 metres being the most usual.

The headroom varies a great deal in different sheds and presents little uniformity. A height of 6 to 7 metres is most commonly met with on the ground floor. At Antwerp the sheds are 58 metres in width but have only 5 metres headroom, so that they are to a great extent dependent upon supplementary artificial lighting. The height of 9 metres adopted at Bremen is determined by the need for very good natural lighting of the ground floor for the handling of fruit.

In general, natural lighting of the ground floor is not considered a question of major importance. Artificial lighting is held to be a more economical solution than to construct a higher building for taking advantage of daylight.

At some ports a headroom of 3 to 3.50 metres is considered sufficient on the upper floor; at other ports this may be as high as 6 metres.

Daylighting of the upper storey is usually effected by means of side wall glazing, but north-light glazing (Antwerp) or rooflights (Bremen) are sometimes employed.

While sheds are generally constructed entirely of reinforced concrete, steel roof trusses have been adopted at Bremen.

As has already been mentioned, new structural methods employing prestressed concrete, precast concrete units, high-tensile reinforcement bars, etc. have resulted in the provision of larger areas of unobstructed floor space than used to be economically attainable in the construction of the heavily loaded floor over the first storey.

A consideration of the superimposed loadings for which the upper floors of sheds have been designed shows that these loads range from 500 kg/m^2 in the sheds of the West-India Docks in London to 1,000 and 1,200 kg/m^2 (Antwerp), 1,500 kg/m^2 (Bremen), 1,640 kg/m^2 (Kandla) and 2,000 kg/m^2 (Copenhagen, Bangkok). The loading of 3,000 kg/m^2, as adopted at Dakar, may be regarded as exceptional, but is understandable if it is borne in mind that in this case lorries have access to the upper floor by means of ramps and are loaded or unloaded there.

Two-storey Transit Sheds at Seaports—continued

What additional allowances for dynamic impact effects have been made with respect to the above-mentioned loads are not known.

At Bangkok the ground floor loading is limited to 2,000 kg/m², and at Kandla it is limited to 2,190 kg/m², in order to avoid overloading the piled foundations that are necessary in these cases; very often, however, no maximum loading is stated, the subsoil being capable of taking any desired loading.

The strong floor over the first storey is invariably constructed with a supporting structure of beams and columns. According to the type of construction employed, the column spacing in the two principal directions varies between 6.46 x 7.60 metres (Calcuttta) and 13.00 x 13.00 metres (Dakar). The floor area supported per column ranges from about 50 to about 170 m². From the considerable differences displayed by the intermediate values, viz. 75 m² (Bremen), 91 m² (Copenhagen), 108 or 112.5 m² (Antwerp), it can be inferred how variously the importance of wide spacing of the columns is judged.

A very important factor in this connection is the question whether lorries have access to the ground floor of the shed or whether only special vehicles for use in transit sheds (electric trucks, piling machines etc.) are permitted. The former system is to be found at Antwerp and Dakar, the latter at Bremen.

For economical construction, the column spacing in the upper storey is linked to that in the lower storey, being either equal to the latter or a multiple thereof—usually twice (Bangkok, Calcutta, Bremen). Columns supported on a spanning beam occur only in the Levant Shed at Dieppe. The columns, beams and floor slab are designed in accordance with the normal rules for reinforced concrete construction. Haunchings at the supports of the beams are sometimes dispensed with; the columns are made square or rectangular; at Copenhagen round columns are employed, which are undoubtedly better from the point of view of operation of the shed, but are more expensive to construct.

All the sheds investigated have a verandah on the upper floor, at least on the water side, so as to be able to take full advantage of the possibility of discharging goods directly into the shed by means of quay cranes.

The widths of such verandahs range from 3.0 metres (Calcutta, Dieppe) to about 10.50 metres (Dakar); in the latter case the verandah also serves as a road for lorries on the upper floor. The width most generally adopted is about 4.0 metres; widths such as 6.66 metres (Bangkok) or 7.50 metres (Piraeus) were governed by the column spacing.

Various structural solutions are available for the verandah on the water side. In some cases it forms part of the floor slab over the first storey; in other cases a cantilevering slab is preferred, the negative cantilever moment serving to relieve the mid-span moments of the inner beams.

It is not known what allowance has been made, in the design of other sheds, for load increases or dynamic impact effects occurring when loads are dumped on the verandah. At Bremen, the verandah slab was designed for a loading of 4,000 kg/m², while its supporting beams were designed for 3,000 kg/m², inclusive of allowance for dynamic effects.

TECHNICAL DATA FOR TWO-STOREY TRANSIT SHEDS Fig. 2

Fig. No.	PORT Location or Designation of Shed	Length	Width Upper Floor / Ground Flr.	Approx Total Area	Height of Storey and Clear Headroom: Ground	Upper	Distance between Columns at: Roof Trusses	Intermediate	Area per Column or: Ground Flr.	Upper Flr.	Structural Framework	Permissible Live Load in kg/m²: Ground Floor	Upper Floor	Width of Verandahs on Upper Floor: Waterside	Rear	Special Handling Appliances	Other Features	Literature Reference
		m	m	m²	m	m	m	m	m²	m²				m	m			
3	ANTWERP LEOPOLD DOCK Compagnie Maritime Belge	2 x 160 = 320	54·0 / 58·0	31,000	7·00 / 5·50	..... / 3·70	10·00	11·25	112·50	112·50	Reinforced Concrete	No Limit	1200	4·50	.....	Electric Winches over Hatchways at Rear Side - Movable Chutes	Contains - Shipping Cos & Customs Offices etc. Accommodation For Ships Personnel	Intern. Shipping Congress 1953 Report S II - C2 page 37
4	ANTWERP SCHELDT QUAY Shed 26	approx 215	26·0 / 26·0	14,200	7·00 / 6·00	..... / 3·50	12·00	9·00 / 8·00	108·00	108·00	Reinforced Concrete	No Limit	1000	4·00	.....	.....	No Walls on Ground Floor, for Unobstructed passages of Vehicles	as above
5	BANGKOK NORTH, SOUTH & EAST QUAYS Sheds 6-10	300	40·0 / 50·0	27,000	7·60 / 6·50	..... / 6·00	upper 20·00 lower 10·00	6·67	66·70	133·40	Reinforced Concrete	2000	2000	6·67	3·34	Lifts	Connected to Warehouses by Bridges at Upper Floor Level.	Hansa 1953 p. 1475
6	BREMEN EUROPE DOCK Shed 6	300	36·50 / 36·65	19,200	9·00 / 7·30	..... / 6·00	9·40	upper 16·00 lower 8·00	75·00	149·00	Reinforced Concrete Steel Lattice Roof	No Limit	1500	4·00	3 Loading Platforms each 2x5m	6 Lifts of 2 Tons each Electric Winches over Hatchways. Chutes	On Ground Floor:- Heating Plant for Fruit Trade in Winter	Hansa 1955 p. ...
7	CALCUTTA KING GEORGE'S DOCK	upper app 122 lower app. 100	46·90 / 32·25	8,930	.....	.....	upper 15·20 lower 7·60	6·46	49·10	98·20	Reinforced Concrete	.....	.....	3·05	.....	6 Lifts 2 Chutes	Rear Railway Tracks incorporated in the Sheds. Special Loading Platforms	Dock and Harbour Authority April 1952 page 69
8	DAKAR MOLE I	approx. 65	26·00 / 39·00	3,900	..... / 1M 6·50	..... / 5·65	13·00	13·00	169·00	169·00	Reinforced Concrete	No Limit	3000 Roof 1500	5·00 plus Road 4·60	Road 11·30	Lifts - 5 Tons Chutes	Upper Floor accessible to Lorries by Ramps	"Travaux" 1954 No 220 p. 48
9	DIEPPE MOROCCO - QUAY LEVANT SHED	approx 280	app. 23·30 / 23·30	13,000	6·00 / 4·75	..... / 3·00	.....	upper abt 7·70 lower 11·60	.....	.....	Reinforced Concrete	.....	.....	3·00	.....	.....	Banana Handling Appliances	"Travaux" 1954 April Number p. 250
10	KANDIA INDIA	approx 137	36·60 / 42·70	10·850	7·15 /	..... / 3·65	.....	7·32	.....	.....	Reinforced Concrete	2190	1640	6·10	.....	2 Lifts of 2 Tons each 2 Lifts of 4 „ each Bag Chutes	Connected to Warehouses by Bridges at Upper Floor Level	"The Port Engineer" (Calcutta) April 1954 p.4 et seq.
11	COPENHAGEN TI METER BASIN EAST ASIAN COMPANY	approx 120	40·00 / 40·00	9,600	7·00 / 5·75	..... / 5·35	9·10	10·00	91·00	91·00	Reinforced Concrete	No Limit	2000	3·10	2·10	2 Lifts. El Winches over Hatchways at Rear Side	Internal Accommod^n for Storage of Provisions - Offices etc.	.....
12	LONDON WEST INDIA DOCKS IMPORT - NORTH SIDE	approx 132·5	33·55 / 36·75 / 39·00	14,400	7·80 / 6·43	5·15 5·05 / 3·78 4·05	7·32	12·20 / 14·65	1M 91·5	1M 91·5	Reinforced Concrete	No Limit	500	4·72	Separate Loading Platforms 1·50m wide	Travelling Roof Cranes of 1·5 tons each.		Dock and Harbour Authority Sept. 1954 p. 150
13	PIRAEUS GREECE	.....	30·00 / 35·00	.....	6·50 /	..... / 5·50	.....	6·10	.....	.....	Reinforced Concrete	No Limit	.....	6·00	3·00	.....	Extension after War Damage	Dock and Harbour Authority Dec. 1952 p. 227
14	ROTTERDAM RHINE HARBOUR Holland America Line	.....	48·10 / 48·10	.....	6·00 / 4·30	..... / 5·40	.....	13·60 / 14·20	.....	.....	Reinforced Concrete	No Limit	.....	app. 3·00	app 1·40	.....	Conversion after War Damage	.....

The parapet construction at the front edge of the verandah varies from a simple kerb beam in some sheds to a 0.90 metre high reinforced concrete wall in others (Bremen, Bangkok); in many cases removable tubular railings or posts with chains are provided for the protection of the dockers. A solid parapet wall makes for increased safety, and the somewhat greater height to which crane loads must then be lifted is unimportant.

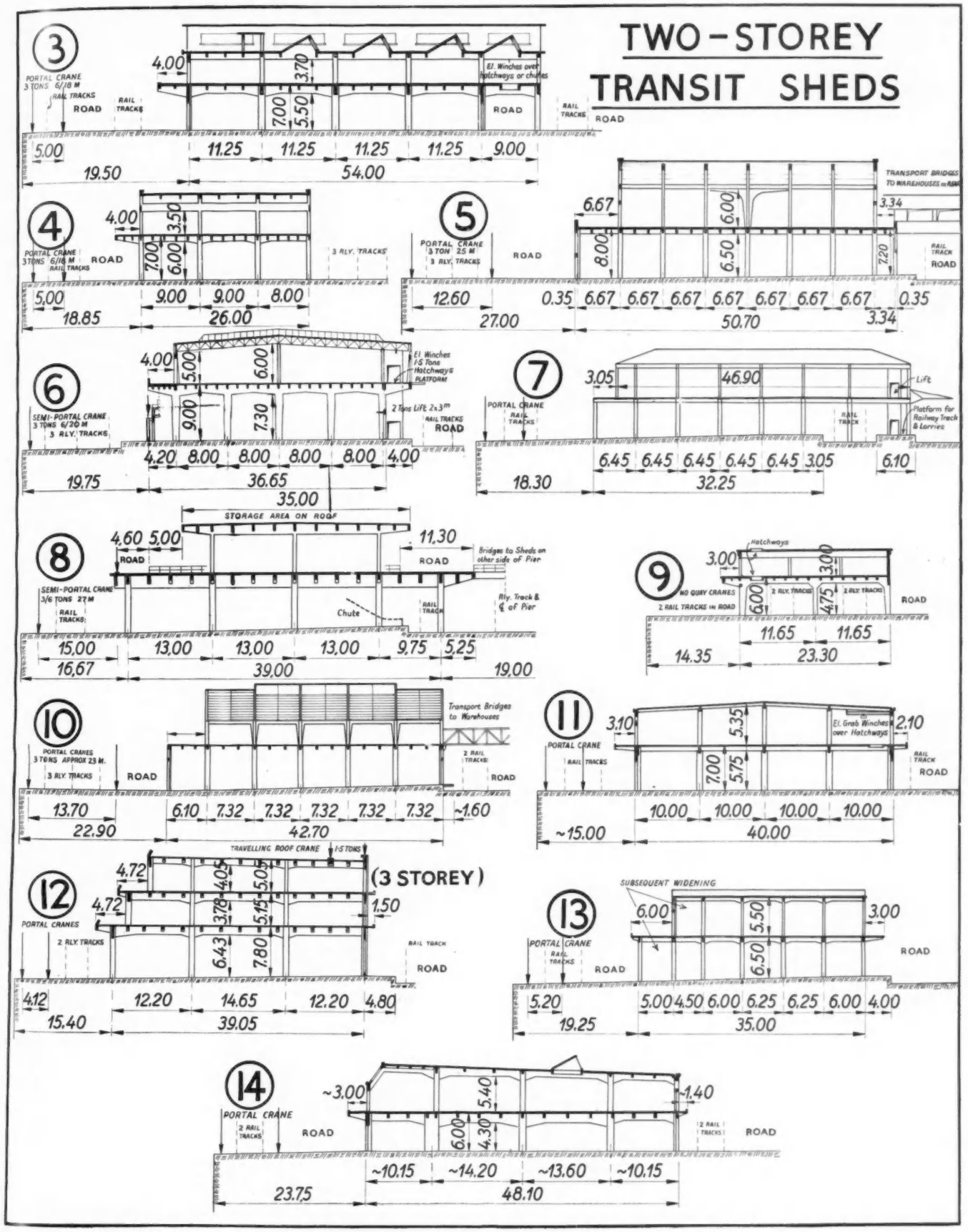
Some sheds also have continuous first floor verandahs on the rear or landward side, though these are generally much narrower. At Bremen, separate cantilevered loading platforms 2.00 x 5.00 metres in size were considered sufficient; many sheds have nothing at all.

As in single-storey sheds, ground floor platforms in two-storey sheds differ widely, according to the traditional practice of the individual ports. Some sheds have ground floors that are at quay level throughout; in others, the ground floor is at quay level on the water side and slopes upward to form a loading platform at the rear of the shed; finally, there are sheds which have a loading platform 0.80 to 1.10 metres in height (depending on the railway rolling stock gauge) on both sides. The provision of such ground floor platforms is in any case not a characteristic feature of a two-storey shed.

Transport Facilities.

On the other hand, the two-storey shed presents the possibility of gaining additional space on the upper floor by making the shed

Two-storey Transit Sheds at Seaports—continued



Two-storey Transit Sheds at Seaports—continued

large enough to accommodate part of the rearward area for road and rail traffic inside it.

At Dakar, one railway track at the rear has been included within the shed and is thus located between the loading platform and an outer row of columns.

At Calcutta, two tracks are accommodated inside the shed; a second row of columns stands on a special platform, the outer side of which can serve for the loading of lorries. The lifts for vertical transport of goods between ground floor and upper floor are installed on this platform. This latter arrangement presents the attractive possibility of sharply separating the different movements of goods if the ground floor lorry loading facilities are located at the ends of the shed or on the water side, or if lorries are allowed inside the shed itself.

The inclusion of a railway track inside the building at the rear side is not a new idea and has, for instance, already been in use for a long time in the multi-storey warehouse sheds of Swedish ports. It is mentioned here only as one of the advantages that may be derived from adopting the two-storey form of shed construction.

Instead of railway tracks, the rearward extension of the shed can equally well be made to accommodate lorries, which can be loaded from the upper floor by means of cargo chutes (Antwerp, Compagnie Maritime Belge).

The value of a two-storey shed from the point of view of operation is determined by the available cargo-handling appliances for ensuring the smooth movement of goods to and from, or between the two floors.

On the water side nearly all sheds are equipped with portal cranes or semi-portal cranes of the usual type, having a long radius and capable of serving both floors.

At the rear of the sheds, various handling appliances are usually provided, goods lifts being the most reliable and versatile but also the most expensive method of vertical transport, which is used only to a limited extent on account the higher initial outlay involved. From the available data the following figures have been compiled with regard to the lifting capacity and the area of upper floor served by one lift:

	Lifting capacity	Area
Dakar	5,000 kg	1,560 m²
Bremen	2,000 kg	1,600 m²
Copenhagen	2,000 kg	2,400 m²
Kandla	2,000 kg and 4,000 kg	1,400 m²

Crab winches—usually electrically driven and running on an overhead rail—are often used to supplement the expensive lift, or are employed in lieu of the latter. These winches raise or lower goods through special hatchways in the floor of the upper storey. This type of lifting device has the advantage of costing a mere fraction of the cost of a lift, but has the drawback of possessing a smaller lifting capacity and being less reliable for continuous duty.

The upper storey floor area served by one crab winch is 960 m² at Bremen and 800 m² at Copenhagen.

Chutes are a third popular method of conveyance, either fixed (Dakar) or capable of being slewed to any desired position about their upper point of suspension (Gare Maritime, Antwerp). The simplest method is to haul an ordinary chute up to the hatchway where it can be most advantageously used (Bremen).

Lifts, crab winches and chutes can adequately meet the requirements as to vertical transport of goods at the rear of two-storey sheds.

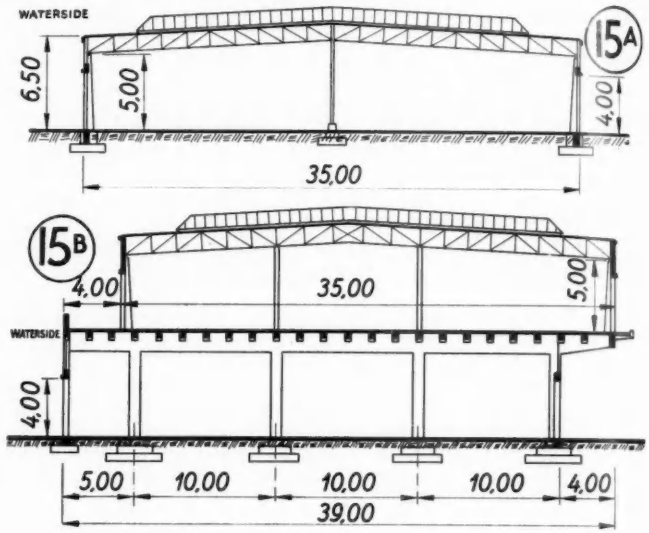
In sheds provided with a rear verandah on the upper floor (Bangkok, Rotterdam, Piraeus, Copenhagen) or with constructionally cheaper individual cantilevering platforms (London, Bremen) it is in special cases also possible to use a mobile crane for upward or downward cargo transport.

At the West-India Docks in London, travelling roof cranes—which are often employed at British ports—are installed at the rear side of the sheds, two such cranes, each of 1.5 tons capacity, serving a length of shed of about 132 metres; this type of crane is undoubtedly a versatile and highly mobile piece of equipment for the vertical transport of goods and as an aid for the loading of vehicles.

The above general survey states the essential technical features of a two-storey shed as contrasted with a single-storey shed. The provision of staircases, artificial lighting on the ground floor, etc. are obvious requirements.

Summarising, it can be said that from the technical point of view it is possible, at an economically justifiable cost, to build two-storey sheds that are able to meet a variety of requirements with regard to their operation.

The buildings erected since the last war embody the fulfilment of a wide range of users' wishes with regard to spaciousness, permissible floor loads and mechanical hoisting gear.



Cost of Construction.

The argument of the considerably higher cost of construction and higher operating costs, which is put forward over and over again, calls for some clarification.

It is misleading merely to compare the cost of construction of single-storey and two-storey shed structures, even if the comparison is based on useful floor areas of equal size, as will be apparent from the approximate figures given below.

It is obvious that in the case of the two-storey shed the heavy foundation, the high cost of the strong upper floor with its beams and columns, and the cost of lifts, crab winches, etc. must increase the costs.

For the purpose of a rough comparison of costs, consider on the one hand two single-storey sheds, each having 35 x 300 = approx. 10,000 m² useful floor area, and on the other hand a two-storey shed with an area of about 20,000 m². The sheds are assumed to possess the following structural features (see Fig. 15a and b):

(a) **Single-storey:** Reinforced concrete framework with faced brickwork infilling, concrete floor with hard concrete wearing surface, central row of columns, timber roof trusses, timber sheeting with roofing felt, transverse roof-lights presenting about 20 per cent. of light-admitting surface in terms of floor area and located at intervals of 10 metres corresponding to the spacing of the trusses. No raised platforms are provided on the water side or at the rear of the shed, the floor of which is therefore at quay level throughout.

(b) **Two-storey:** Reinforced concrete framework, etc., as in the single-storey shed, with column spacing of about 10 x 10 metres in lower storey; upper floor designed for 2,000 kg/m² useful load. The mechanical equipment comprises a total of 6 lifts and 9 crab winches, while the structure must furthermore be provided with 3 staircases.

Both types of shed are assumed to contain simple accommodation for administrative and customs purposes and to be provided with the necessary electrical equipment for lighting and power in accordance with modern requirements.

The cost of construction has been approximately estimated on the basis of the prices ruling in the autumn of 1954; the total cost

Two-storey Transit Sheds at Seaports—continued

may, of course, vary within certain limits, depending on the particular requirements imposed.

The costs are as follows:

single-storey shed	approx.	1,250,000 DM
i.e., for a useful floor area of about 10,000 m²	approx.	125 DM /m²
two-storey shed	approx.	4,000,000 DM
i.e., for a ground floor area of about 10,000 m²	approx.	400 DM /m²
or, related to the useful floor area of about 2 x 10,000 m²	approx.	200 DM /m²

The total costs are therefore roughly in the ratio of 1 to 3.2. The costs per square metre of useful storage space are in the ratio of about 1 to 1.6.

The significance of the limited serviceability of the upper floor with regard to very heavy loads (loading not to exceed 2,000 kg/m²) and bulky objects can, of course, be variously judged. The close spacing of the columns could likewise be regarded as impairing the usefulness of the ground floor. To what extent these limitations constitute a disadvantage in the operation of the shed can only be judged for each particular case individually. A critical assessment of the question requires this possible drawback to be pointed out, however.

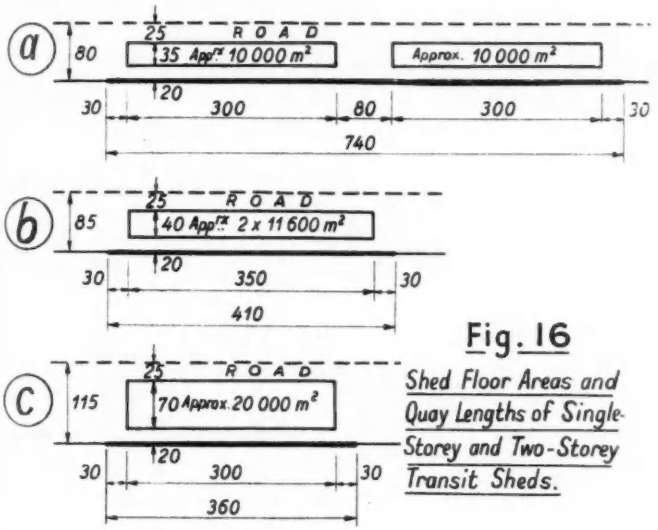


Fig. 16

Shed Floor Areas and Quay Lengths of Single-Storey and Two-Storey Transit Sheds.

In order to obtain, in the two-storey shed, a useful area equivalent to that of two single-storey sheds with a total floor area of approximately 20,000 m², it would, for instance, be conceivable to give the two-storey shed a length of 350 metres and to make up for its somewhat lower floor efficiency by effecting a 16 per cent. increase in floor area. The costs would then be as follows:

single-storey shed	1,250,000 DM
two-storey shed 1.16 x 4,000,000	4,650,000 DM

The cost of construction per square metre of useful storage space now becomes approximately 125 and 232 DM respectively, i.e., approximately in the ratio of 1 to 1.85 as against 1 to 1.6 previously.

The above comparisons of costs should be regarded only as general indications; they are likely to vary according to special requirements and the cheaper or more expensive methods of construction adopted.

It should be taken into account that the above estimates only allow for the shed structure itself, together with its complete equipment, but do not include the necessary additional features such as the quay, cranes, railway tracks, roads, etc.

In the points set forth below, the problem of the cost of construction is dealt with on the broader basis of the total cost of a port, which is undoubtedly a more important consideration than the cost of individual structures as has so far been discussed.

The task of economically providing cargo-handling facilities comprising some 20,000 m² of shed area leads—in borderline cases—to the solutions shown in Fig. 16:

(a) Two single-storey sheds, each 35 x 300 metres in size and thus having a total floor area of about 20,000 m², with approximately 740 metres of quay and with railway tracks and roads of appropriate length and about 12 modern movable cranes.

(b) A two-storey shed with a ground area of about 35 x 350 metres = 11,600 m², or 23,200 m² of equivalent useful floor area, with a quay approximately 410 metres in length, likewise equipped with railway tracks and roads of appropriate length and about 8 cranes.

(c) It is assumed that a solution embodying a single-storey shed with a floor area of 70 x 300 metres = approximately 20,000 m² must be rejected as impracticable on account of the great depth of the structure, for which the necessary space is seldom available. From the point of view of shed operation a depth of 70 metres might be regarded as the extreme limit for economical horizontal transport and would — except in special cases where large quantities of uniform cargoes are handled, e.g., wool—call forth the same kind of criticism as is levelled against the two-storey shed.

In order to arrive at a comparative estimate of the cost of the two quays, with lengths of 740 and 410 metres respectively, needed for accommodating about 20,000 m² of shed area, it is necessary to fix uniform basic costs for the main constructional work and inclusive of all subsidiary work to be carried out in conjunction therewith; here, again, these figures are to be regarded only as general indications which are likely to vary according to local conditions and particular requirements. The following approximate figures can be given:

1 linear metre of quay wall for about 10 metres depth of water, exclusive of large-scale dredging (if any) before the quay	approx.	10,000 DM /m
1 square metre of paving for heavy lorry traffic, with base ...	approx.	65 DM /m²
1 linear metre of railway track laid flush with the paving, with switches, etc.	approx.	200 DM /m
1 linear metre of service mains, e.g., electric cables, water supply, sewerage	approx.	250 DM /m
1 modern crane, of 3 tons lifting capacity and about 20 metres radius, per 25 linear metres of quay	approx.	125,000 DM

With these rough figures for the cost, and for the dimensions shown in Fig. 16, we obtain:

(a) 740 metres of quay with about 20,000 m² of useful floor area in two single-storey sheds—total approximately 15 million DM.

(b) 410 metres of quay with about 23,200 m² of useful floor area in one two-storey shed—total approximately 11 million DM.

The overall costs of the two schemes are therefore in the ratio of 1 to 0.73 in favour of the two-storey shed.

Thus, from the point of view of the **total** capital cost, the two-storey shed possesses definite advantages, which in turn affect the depreciation costs and the interest on outlay.

Even though the cost of construction of ports is viewed on the whole as "lost expenditure," the difference in the magnitude of the outlay required is nevertheless of influence on the schemes to be drawn up for financing the project and cannot be disregarded by the financing authority.

Operating Costs.

Whereas the cost of construction can be estimated with a fair degree of accuracy, the increased operating costs, which are often produced as an argument against two-storey sheds, cannot be expressed in figures on which it is possible to base a reliable comparison. One important reason for this is that the calculation of

Two-storey Transit Sheds at Seaports—continued

operating costs belongs to the trade secrets of every port-operating company and publications on the subject can hardly be expected, however much it would be desirable for the operating undertakings openly to adopt a certain standpoint on the basis of facts and figures.

In the absence of figures we can only be guided by the following line of reasoning:

Starting from the assumption that, in the case of the two-storey transit sheds hitherto erected, commercial as well as technical considerations have played a decisive part, it can at once be inferred that the objection as to the increased operating costs is in any case variously judged. The expected increase in operating costs in evidently less than the expected rise in profits due to the increased floor area, for it is hardly likely that a building of this kind would be erected with the intention of having to subsidise its operation !

Summary.

The prejudice that has hitherto existed—especially in German ports—against the construction and operation of two-storey transit sheds for general cargo (and which has been based on theoretical considerations rather than on actual practical experience) must give way to the knowledge that the two-storey shed deserves due consideration in port reconstruction schemes. In all cases where, owing to lack of space, the existing port area, which is incapable of further extension, has to be utilised as extensively as possible, there is the welcome possibility of doubling the shed floor area required near the quayside, without loss of space, by adopting the two-storey shed, or even of further multiplying the floor area by the construction of multi-storey buildings.

The two-storey shed closely conforms to the principle of industrial organisation that the trading results of an undertaking can be improved by achieving the highest possible degree of concentration of the equipment and the intensified use thereof.

The greater available shed floor area per linear metre of quay permits an increase of the amount of cargo handled per linear metre, more extensive utilisation of the quay cranes (which previously had actually worked for about only one-third of their nominal working time), and also more intensive utilisation of the railway tracks, roads, etc.

It stands to reason that this improved utilisation of the cargo-handling facilities entails certain increases in expenditure for the construction of the sheds. The actual shed building is made dearer by the heavier structural members employed and by additional appliances such as lifts, etc., while the cost of the installation as a whole is increased by the need for providing it with railway and road facilities of appropriately increased capacity for dealing with the greater density of traffic.

The summary of the technical data relating to two-storey sheds built since the end of the last war shows the great diversity of requirements that can be satisfied in a modern seaport by this type of transit shed.

Reduced Congestion at Basrah

Improvement in Turn-round

The Port Directorate of Basrah reports that as a result of drastic reorganisation and reconstruction the congestion in that port is now much reduced. The results were achieved in the face of increasing congestion in the transit areas due to three main factors: (1) Low river levels between Baghdad and Basrah which practically stopped river transport. (2) Inability of the railways to cope with imports, especially the large quantities of steel and heavy items, because of the shortage of flat trucks and specials and general difficulties of handling and storage in Baghdad. (3) Lack of storage space in the country generally and consequent use of port warehouses and dumps by merchants for storage.

Twenty-four Hour Working.

In spite of all difficulties the turn-round of ships has been steadily improving so that there is practically no waiting for berths and discharge is reasonably good in spite of limited available storage space. The steps taken to effect improvements in the situation and to deal with the exceptional number of ships and the larger tonnages of imports have been as follows:

Considerable reorganisation in traffic administration and operation, including the appointment of key men as assistant traffic officers with sectional responsibilities and authority; greatly increased staff of tally clerks and sorters and increased labour for cargo handling; greatly increased supervision and drive on the wharves by day and night; drastic alteration of system of berthing allocation; introduction of 24 hour working at lighter berth and formation of mobile units working at night mainly for the transfer of heavy wharf cargo and for clearing bottle-necks (each unit is complete with tally clerks, serang and labourers, quay crane driver and mobile crane driver); utilisation of heavy transport for transfer of heavy and bulky wharf and dump cargo from wharves and operational areas convenient for road and railway delivery; and considerable increase of port's fleet of mobile cargo-handling appliances, including Hyster 7½-ton fork lift and numerous mobile cranes.

New Construction.

The following are constructional improvements reported by the Port Directorate: Utilisation of King Ghazi Pier at Ashar (which was under construction) and completion of special arrangements on pier and apron and in the Ashar sheds for accommodation of the weekly mail (when possible ships with small and suitable tonnage are also discharged there between Wednesday and Saturday); No. 10 Wharf brought into use under temporary arrangements, ships being brought alongside pontoons moored to four dolphins, cargo manhandled from ships' derricks down gangways into an enclosed open area floodlit at night and guarded night and day by a special security force; extension of transit area and acceleration of hard surfacing and levelling of wharf aprons and roads and railways between sheds and warehouses, now nearing completion.

Further construction work in hand is the erection of two new transit sheds at No. 9 and 10 berths which will shortly be completed. A long-term development now starting is the complete reconstruction of No. 2 wharf.

Special Efforts by Traffic Staff.

The traffic staff, realising that changed conditions call for a change in outlook and methods, are doing everything possible to speed the turn-round of ships, when necessary applying traffic regulations with suitable discretion.

Ships are pushed into allocated berths as quickly as possible and discharge commenced from one or two hatches (rather than keep vessels waiting any longer than can be avoided) in spite of some congestion on wharves and in sheds. It is calculated that the new system of berth allocation is saving shipping companies a very large sum over the year.

Kenya Harbour Development

Big Expenditure Recommended

The Transport Advisory Council has recommended spending nearly £3 million for new railway and port works in East Africa, of which £500,000 are proposed to be spent on completing a new berth in Mombasa.

It is hoped to start work on the new berth soon and bring it into use by the end of the year.

The council has also recommended that a further £5 million loan should be raised to cover the cost of building new deep-water berths on the mainland opposite Mombasa, and other works.

Among other projects proposed for Kenya are industrial siding facilities at Naivasha, improvements in the branch line from Voi to the Tanganyika border and Moshi, and improved telephone and signalling facilities in Mombasa.

A New Fender System

Retractable Type at New York Naval Shipyard

By Commander PALMER W. ROBERTS (C.E.C.), U.S.N.
and
Mr. VIRGIL BLANCATO, Structural Engineer.

The following account of a new type of retractable fender system is based upon an article that appeared in the June 1955 issue of the BuDocks Technical Digest, of the Bureau of Yards and Docks, U.S. Navy Department and augmented by further data supplied by the Bureau.

In his review of the article, the Bureau's consultant on waterfront structures points out that the retractable fender system described is not generally suitable for open type piled wharves, piers or jetties. He adds however that on solid quay walls such a system may serve to great advantage. It should be noted also that the system is more particularly applicable to structures on inland waterways and elsewhere, where there is not a great variation in water levels.

A 104-ft. trial section of a new retractable fender system for piers, installed in Pier K at the New York Naval Shipyard in 1954, has proved to be far more effective than the conventional systems previously used. The benefits accrued from the new fender include:

1. Lower initial cost;
2. Ease of fabrication and installation;
3. Capacity for absorbing a larger amount of energy of impact, affording better cushioning between the moored vessels and the pier;
4. Resistance to superior striking forces, eliminating breakage of the various members of the fender;
5. Economy in maintenance cost; and
6. Section can be easily replaced, if required.

The retractable system (shown in Fig. 1) consists of vertical contact fenders, 12-in. x 14-in. x 14-ft., spaced 8-feet o.c. (in lieu of piles of the conventional system), bolted to 3 rows of 8-in. x 12-in. wales which are fastened on 12-in. x 12-in. holding posts. The posts are suspended by 6—$1\frac{1}{4}$-in. diam bolts on the slotted holes of two steel U-shaped brackets fastened to the sea wall.

When the fender is subjected to a force greater than the resultant of its weight in the direction of the slots and the friction of the bolts, it will retract backward and upward for a distance of 3-in. The posts will then bear against the back of the brackets, and the wales, after deflecting $\frac{1}{2}$-in., will come to rest against a vertical bearing-board fastened to the sea wall. The improved capacity to absorb energy of impact stems from the fact that when a fender is pushed back, two or three posts at each side intermittently follow the movement, thus gradually increasing the resistance to the acting force. This system, under such action, absorbs many more times the energy of impact than the conventional two-row, double-wale system. Further, it is well protected from damage as the residual force of impact is transmitted directly to the sea wall.

In most piers the relieving platform is located two or three feet above mean low water level, and in the conventional pile fender system the lower wale, on which the pile is fastened, is located from 5 to 6 feet above this level. At low tide, the camels, which are interposed between the moored vessel and the fender system, often strike the piles with hard blows and break the unsupported pile. When this occurs, the upper wale, to which the top of the pile is connected, is pulled out and broken by the leverage exerted by the pile bearing on the lower wale.

In the retractable system (Fig. 1), the posts extending below the relieving platform, are adapted with a third wale at mean low water proximity, which gives a valid bearing to the fender stub. The upper bracket (Fig. 2) is provided with L-shaped slots to permit the upper portion of the fender system, when hit at low level, to move upward and outward. The lower portion of the system then moves upward and inward. Guided by the slotted holes of the lower brackets, it bears on the stop board for added resistance to the acting forces (Fig. 3).

A static pressure test was performed on a trial section of the retractable fender system to determine the force required to move one fender back to its resting position, and to observe the general behaviour of the various structural members of the system when subjected to stress. Test pressures were provided by a 50-ton hydraulic jack bearing on a frame fastened to the sea wall and acting on a fender at a point one foot above the middle wale. The following is a schedule showing fender displacement versus applied pressure.

Applied Pressure Tons	Fender Retraction Inches	Retraction of 1st pair of adjacent posts (one each side of pressure point) Inches	Retraction of 2nd pair of posts Inches
1	Perceptible	None	None
2	$\frac{3}{4}$	$\frac{1}{2}$	None
$4\frac{1}{2}$	1	$\frac{3}{4}$	None
17	$1\frac{3}{8}$	1	$\frac{1}{2}$
30	2	$1\frac{1}{2}$	$\frac{3}{4}$

At 50 tons of applied pressure, the top of the fender retracted 2 3/4-in., the bottom fender-supporting-wale was observed to be resting on the bearing board, the first pair of posts retracted $2\frac{1}{4}$-in., the second pair of posts retracted $1\frac{1}{4}$-in., and the third pair of posts retracted $\frac{1}{4}$-in.

An evaluation of the above data and observed test conditions indicated that when 50 tons of applied pressure were required to retract the fender to its extreme stop position, the six posts participating in the retraction transmitted his force to the bulkhead at six points with varying intensity.

A similar test performed on a pile of the two-row double-wale system revealed that an applied pressure of 18 tons was sufficient to cause a deflection of 1-in. in the two outer wales thereby inducing a stress of 5,000 pounds per square inch. This is considered the limiting stress to which the wales can be subjected.

The aforementioned tests indicate that when a pile of the conventional fender system is subjected to pressure, the wales can absorb a maximum energy of $\frac{3600}{2} \times 1\text{-in.} = 18000$ inch-pounds;

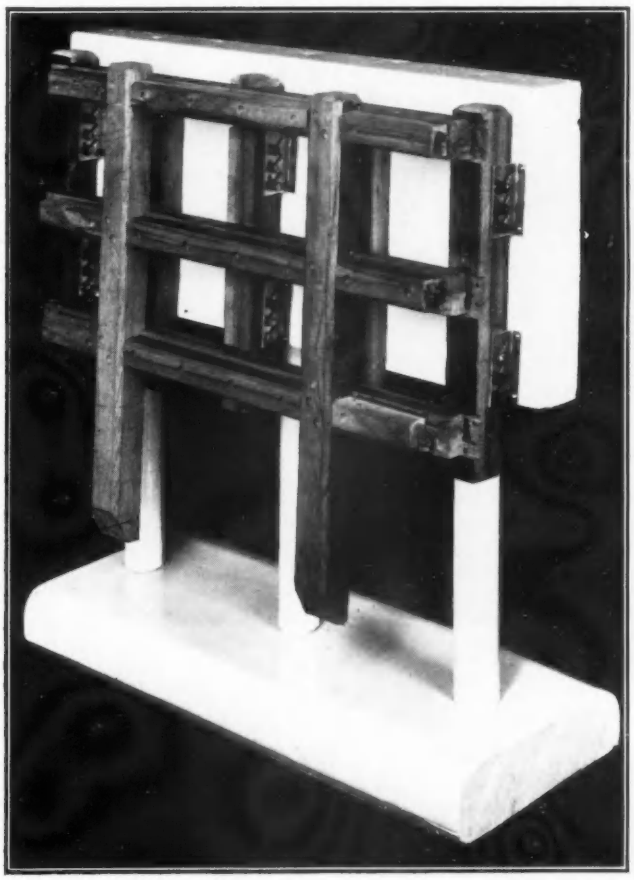


Fig. 1. Model of new Retractable Fender System. Note brackets with slotted holes securing fender to sea wall.

New Fender System—continued

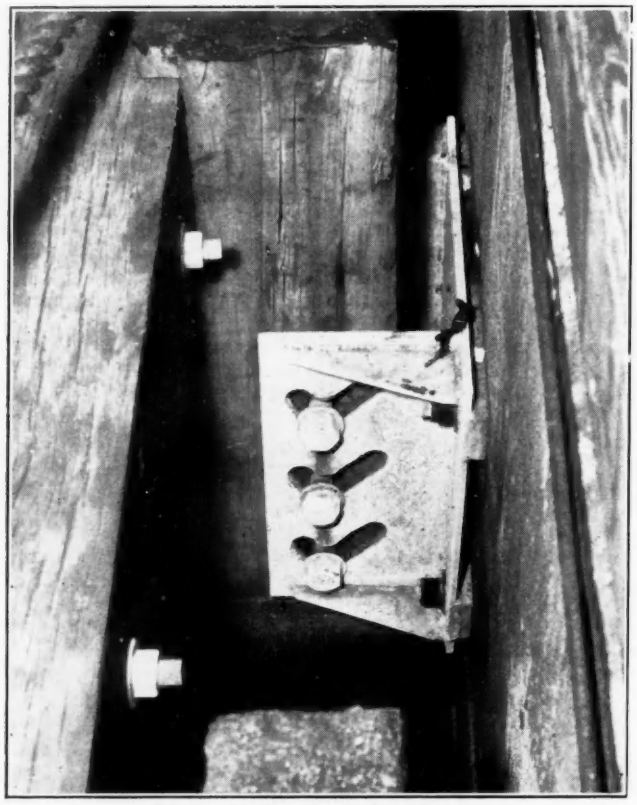


Fig. 2. Fender post in low position.

the energy absorbed by the retractable fender system under the same test conditions is $\frac{100{,}000}{2} \times 3\text{-in.} = 150{,}000$ inch-pounds, or 8 times the energy absorption.

It is also important to note that the retractable system is well protected from damage since the residual force of impact is transmitted directly to the bulkhead.

The component members of this new fender can be fabricated to exact dimensions at the mill, assembled in large sections near the site, and lowered in separate units into the brackets previously installed on the sea wall. This procedure, possible only with this type of fender, eliminates the loss of time deriving from tides and inclement weather, one of the prevailing factors in the high erection cost of the conventional fender system. The cost of fabricating and installing the two steel brackets for each bent is lower than the cost of acquiring and driving a pile in the New York yard.

The maintenance of the new system is anticipated to be very inexpensive. For example, in the 12 months of existence of the 104-ft. trial section (Fig. 2) not a single member has broken. During that time, apart from minor ships, two large carriers, namely USS "Ticonderoga" and the USS "Bennington," were berthed for long periods against this fender in rough weather, including two hurricanes. The conventional system at the same berth, during the same period, suffered considerable damage.

Replacement of a broken fender or wale in the retractable system is a simple matter, the length of the wales being of the length of a bent and the replacement being confined to the broken member. In the conventional system, where the wales by the necessity of obtaining the proper deflection, are of considerable length and the splices of the outer and inner wales are alternated, the removal of a broken wale involves the removal of 3 or 4 bents of the system.

An inspection made recently of the suspending bolts (Fig. 3) indicates negligible wear. This was as expected since a horizontal thrust of over 6,000 lbs. is required to move two posts of the system upward, such occurrence taking place only when the fender system is hit with considerable force by a floating body. It also should be noted that when the posts are in their retracted position they come to rest against the back of the brackets and the bolts cease to be under stress. The function of the bolts is merely to support the weight of the fender system on the brackets. To eliminate the wear due to corrosion the brackets and bolts have been hot-dip galvanised after fabrication.

The replacement of an 88-ft. section of an existing two-row double-wale system with a similar conventional fender system, using greenheart piles and southern pine wales and chocks, would cost about $600 for 8-ft. bent or a total of $6,600.

The replacement of the same section of fender with the new retractable 3 wales system using red oak, will cost $550 per 8-ft. bent, or a total of $6,050.

To replace one outside top wale of the old system, broken at connection point with the pile, necessitates the replacement of a 24-ft. wale and the unbolting and refastening of 3 piles and 6 chocks. This operation requires a period of two days, with a crew of 4 men.

Cost: 8 man/days @ $22.00 =	$176.00
Material: 6-in. x 12-in. x 26-ft. =	31.00
	$207.00

To replace the two lower wales of the old system broken at the pile connection requires the removal of the 24-ft. rear wale and 32-ft. front wale, the unbolting and refastening of 4 piles and 8 chocks. To perform this operation would take 4 days with a crew of 8 men.

Cost: Labour—32 man/days @ $22	$704.00
Material	69.60
Total Cost	$773.60

Replacing any one wale in the retractable system requires the removal of one fender and two chocks, which is done in less than one day by a crew of 4 men.

Cost: Labour—4 man/days @ $22 =	$88.00
Material 1—8-in. x 12-in. x 8-ft.	12.80
	$100.80

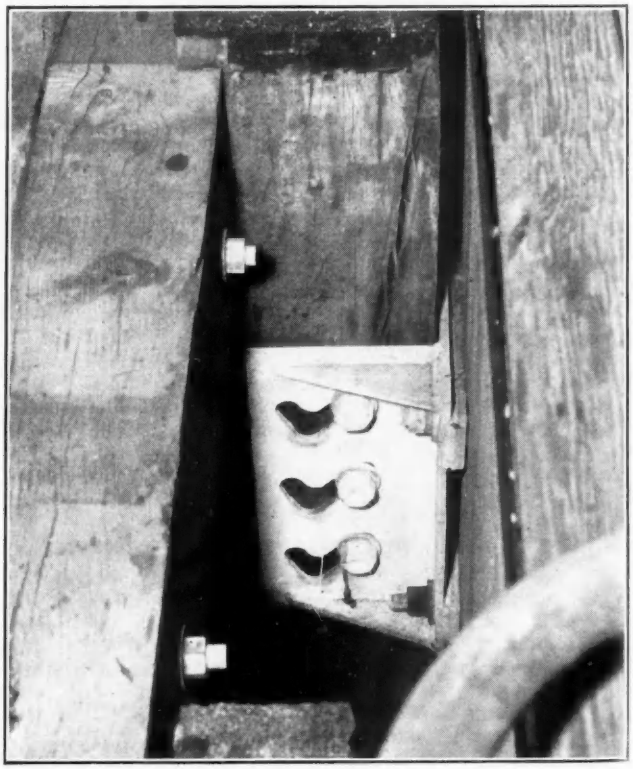


Fig. 3. Fender post raised and resting against back of bracket.

New Fender System—continued

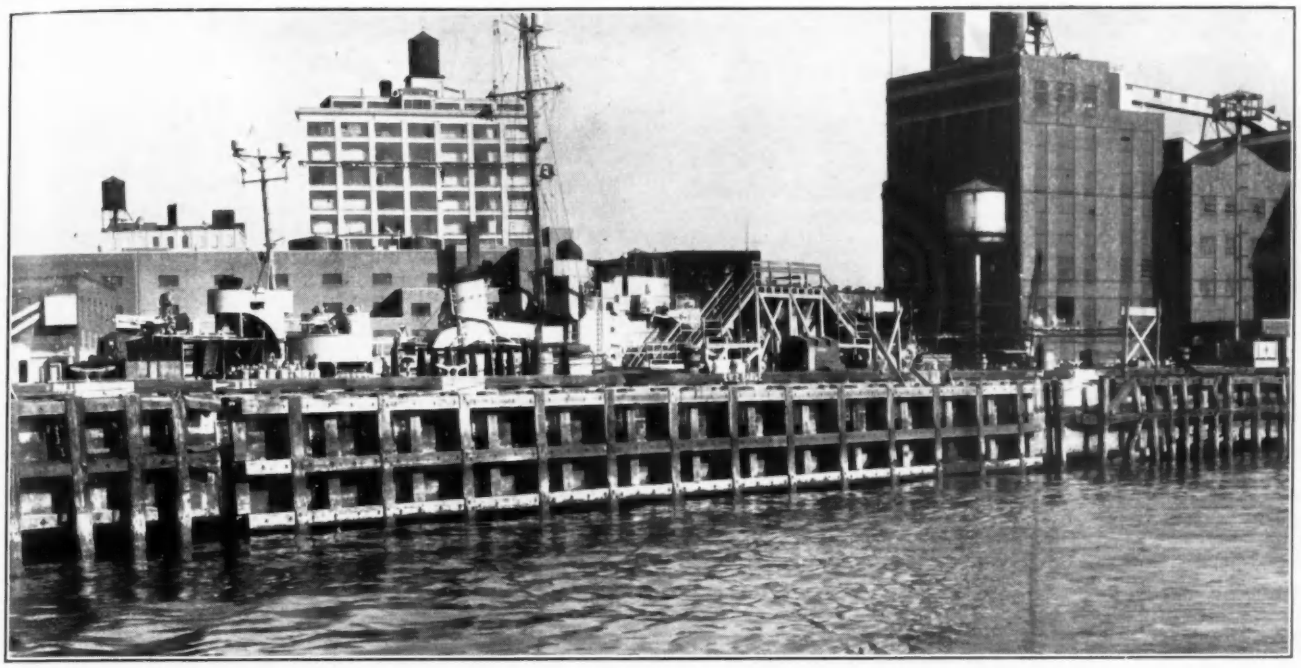


Fig. 4. Trial section of Retractable Fender System at New York Naval Shipyard, Brooklyn.

To replace one 70-ft. pile in the old system requires the assembling of the pile drive equipment, the use of a flat railroad car to transport the pile to the site and the assistance of a crane to handle the pile. With this assistance a crew of 4 men will take two days to replace the pile.

Cost: Labour—8 man/days @$22 =	$166.00
Material 1—70-ft. greenheart pile	$181.00
Cost (not considering the cost of the assistance)	$347.00

To replace a fender in the retractable system, which takes the place of a pile, requires one day with a crew of 4 men.

Cost: Labour—4 man/days @ $22 =	$88.00
Material 1—12-in. x 14-in. x 14-ft.	39.20
Total Cost	$127.00

The problem of replacement of damaged fender systems is common to all waterfront activities. Usually conventional systems are totally repaired twice in fifteen years. It is conservatively estimated that the new retractable system will require only minor maintenance in an equal period. In a facility having the pier space of a naval shipyard, approximately 8,000 lineal feet, a saving of more than $550,000 may result in a period of fifteen years in replacement of fender systems alone.

The above comparative figures of cost of installation and repairs of the two-row conventional double-wale fender system and the new retractable system, in the New York naval shipyard piers, more than justify the early adoption of this new system. Fender systems using this new principle can be designed by altering the size and weight of the members and depth of the slots in the brackets, to make them suitable for both small boat landings and major berthing installations, no matter how critically exposed.

In consideration of the behaviour of the trial section, and the acknowledged potentialities of the new fender system, BuDocks has authorised replacement of the worn-out sections of the conventional system in several of the New York naval shipyard piers with this retractable system.

Bulk Sugar Handling at Greenock

Plans are now in operation for installing a bulk sugar discharging plant at the Port of Greenock to enable raw sugar to be unloaded in bulk from ocean-going vessels. It is estimated that the cost of the installation will be £200,000 and that the scheme will be in operation within the next two years.

The site selected for the plant is the James Watt Dock where existing sheds on the quayside afford considerable storage facilities. When in operation the plant will be managed by the Greenock Bulk Handling Co., Ltd., a subsidiary company of John Walker & Co. (Sugar Refiners) Ltd.

Three 5-ton gross capacity travelling grabbing quay cranes are to be provided, and these cranes will discharge sugar from the ships into adjacent hoppers standing on the quay. As the unloading operation proceeds, trimming to the square of the hatch will be assisted with various mechanical appliances. The hoppers on the quayside will be so arranged that tipping wagons can be filled from them.

Two weighbridges are to be installed so that the tipping wagons can tare weigh and gross weigh and so determine their burden. After weighing, the vehicles can discharge at one or other of the sugar refineries situated in Greenock, or they can be diverted to dockside sheds, where extensive storage facilities are available.

A portable receiving hopper will receive the contents of the tipping vehicles and discharge on to a band-conveyor, which, with suitable auxiliaries, will discharge on to a high speed thrower; this, in turn, will project a stream of sugar so that a pile of bulk raw sugar can be built in the shed.

It is anticipated that by this means a total of 8,000 tons of bulk raw sugar can be stored in one shed and 6,500 tons in another. This quantity might well be increased by providing suitable retaining walls to restrain the pile. The storage facility will be used to counteract the fluctuations in the arrival of vessels.

When it is desired to reclaim sugar from the shed, mechanical shovels will be used to transfer it back into tipping wagons, which will, in turn, take it to the refiners' premises.

Up to the present, raw sugar has come in bags to Greenock, but with the need for increased speed in turn-round of ships the old methods have become uneconomic. With the change-over to bulk handling, Greenock will be the third port in England to discharge sugar in this way, the other two ports being London and Liverpool.

Diesel Shunting Locomotives

Power Requirements and Other Considerations for Docks Estates

By R. H. NICHOLSON, A.M.I.Mech.E., A.M.I.Loco.E.

FULL economic advantage of the diesel shunting locomotive can only be obtained by ensuring its maximum availability for traffic. This in turn depends on a combination of first class maintenance and a positive guarantee that the locomotive is only worked within a certain load range, dependent on its maximum capacity. An engine subjected to frequent overloading remains anything but trouble free, and conversely—low combustion efficiency, and rapid cylinder wear through cold sludging, result if the engine is worked well below its capacity and at speeds less than designed values.

Therefore it is essential that when considering the employment of a diesel locomotive, strictest attention must first be paid to site and working conditions before the engine rating of the unit can be decided.

The writer has had certain experience with this type of investigation and feels that some of the information which he has been able to accumulate might serve as a guide to other Authorities or potential diesel locomotive users. The points put forward are based entirely on the assumption that the user has first concluded that the operation of diesel locomotives can be justified on his estate to economical advantage. For obvious reasons, this is of fundamental importance, and the subject has already been dealt with at some length in a previous article published in this journal.[1]

Resistances.

The main factor which decides the maximum haulage capacity of the locomotive is the combination of resistances to oppose engine power. So far as typical dock or industrial shunting work is concerned, these may be said to arise from track layout, and the type of wagons or rolling stock in use.

Track resistances arise from curves and gradients on the site, and it should be borne in mind that if a given load is required to be hauled from A to B, the tractive effort of the locomotive must be sufficient to deal with the severest of these (or their combination) found en route if train splitting is to be avoided.

(1) **Curve resistance**—R_c

This is usually calculated by the Morrison formula which gives :

$$R_c = 2240 \times \frac{2\,r}{(D+L)} \times f, \text{ lbs/ton}$$

Where D = Rail gauge in feet
L = Rigid wheelbase of wagon in feet.
r = Radius of curve in feet.
f = Co-efficient of friction, usually taken at 0.27.

(2) **Gradient resistance**—R_G

$$R_G = \frac{2240}{\text{gradient}} \text{ lbs/ton}$$

(3) **Starting resistance**—R_s

This value also depends on the condition of the track layout and the type of rolling stock in use, but from the writer's experience the following figures may be used with reasonable accuracy for typical dock or industrial layouts :

(a) 18 lbs/ton for wagons with oil lubricated axles.
(b) 27 lbs/ton for wagons with grease lubricated axles.

(4) **Rolling resistance**—R_R

This is the resistance to the train when on the move, and again is mainly dependent on track conditions and type of rolling stock used. A good all round figure for Docks Estates can be taken as 12 lbs/ton, at least for oil lubricated axleboxes.

The co-relation of values (1) to (4) depends entirely on site conditions, and these must first be thoroughly investigated before the worst overall resistance can be assessed. This usually occurs when starting the train from rest, but if very severe curves or gradients have to be negotiated after the train is under way, the summation of resistances may well be higher than those encountered in starting from rest, even if the train is then partially on a curve. At the writer's establishment, there are 90 miles of track but no gradients. The majority of curves are in the region of 300 feet radius, so in order to apply a common formula to all locomotives over the entire site, loading scales are calculated on a "compromise" basis of a train starting up from rest, half on a 300 feet radius curve and half on the straight. The sum of the resistances R, can then be expressed.

$$R = R_s + \frac{Rc}{2} \text{ lbs/ton}$$

Where R_c = resistance for a 300-ft. radius curve.

Power Requirements.

Having obtained the sum of the most unfavourable resistances likely to be encountered, the required tractive effort of the locomotive may be calculated for a given load at the drawbar :

Tractive Effort required in lbs = R × N
Where R = overall resistance in lbs/ton
N = gross weight of locomotive plus load in tons

In turn, the necessary brake horse power required from the prime mover is co-related to the formula

$$\text{B.H.P.} = \frac{\text{T.E.} \times \text{M}}{375 \times e}$$

Where M = Speed of locomotive in miles per hour
T.E. = Tractive effort in lbs.
e = overall mechanical efficiency of locomotive. This can be taken, generally, as .8 to .85 for mechanical and 0.7 for electrical transmissions.

As the characteristic tractive effort/speed curves for mechanical and electrical transmission are fundamentally different, care must be taken when using the above formula to interpret these values correctly. When starting a train from rest, the tractive effort demand from the locomotive is the highest compatible to adhesion, and this value may be more than double that required subsequently for keeping the train moving.

The rating of the prime mover is, therefore, decided on maximum starting tractive effort required of the locomotive, and with mechanical transmission where the curve is "stepped" at each ratio, the value for M is taken as the maximum speed that can be maintained in the lowest gear, usually in the region of 4 miles per hour. In specifications for diesel locomotives with electrical transmissions, it is the usual practice to give a maximum starting tractive effort (based on the co-relation of the engine's continuous rating and a speed of approximately 4 miles per hour); continuous tractive effort at a certain speed; and tractive effort based on the 1 hour "overload" rating of the prime mover, at a certain speed.

Braking.

The writer well remembers a certain engineer passing the remark —"It isn't what you can pull, it's what you can stop." This point can be very real if such problems as long steep gradients, greasy track or badly sited road crossings have to be contended with, and a study of braking characteristics is always justified at the specification stage of the locomotive. The stopping distance for a given speed and train weight is of fundamental consideration.

(1) Locomotives for Heavy Dock Shunting—A. O. Helps. "Dock and Harbour Authority," June 1951.

Diesel Shunting Locomotives—continued

(1) Stopping distances—level track.

By first principles, a train having a total weight of W tons and running at a speed of V miles per hour possesses kinetic energy, E ft. lbs. Developing the fundamental formula, $E = \frac{WV^2}{2g}$ and adding a 5% allowance for energy stored in wheels and axles, this amounts to 78.5 W V^2 ft. lbs., when W and V comprise the above unit values.

When the throttle is closed and the brakes applied, this energy is absorbed by the various resistances acting on the train, R lbs./ton.

Then the distance in which the train is brought to rest can be expressed as

$$S = \frac{E}{R} \text{ ft.} \qquad \text{Or, } S = \frac{78.5\ W\ V^2}{R}$$

Where W = Total weight of train, including loco. in tons
V = Speed of train at time of brake application in M.P.H.

As this paper deals only with relatively slow speed shunting locomotives, R can be said to comprise the sum of
(1) Rolling resistance—say 12 lbs/ton of train weight.
(2) Curve resistance, if any.
(3) Frictional resistance of brakes.

Resistance (3) is the product in lbs. of the overall leverage of the brake system; the load acting on the brake cylinder piston; and the co-efficient of friction between the brake block and tyre. The determination of this latter value is subject to many variables and an " absolute " value cannot be given. A very interesting analysis of the subject has been given by Koffman[2] but for relatively slow speed dock duties, the writer always uses a kinetic value of γ at 0.22 as a representative mean.

A good approximation of frictional brake resistance, so far as shunting locomotives with all wheels braked and coupled, can be taken as the product of 75% of the adhesive weight of the locomotive in lbs. and the γ value as detailed above.

(2) Stopping distances—down gradient.

Again the stopping distance is derived from the same fundamental expression :

$$S = \frac{78.5\ W\ V^2}{R} \text{ ft.}$$

though obviously the negative gradient resistance must first be subtracted from the sum of rolling and frictional brake resistances in order to assess R.

Adhesion.

This paper is not intended to present a general picture of diesel rail traction, but the potential user should give consideration to the adhesion characteristics of the locomotive at the specification stage. As the highest tractive effort demand from a shunting locomotive is for starting, and as this in turn is governed by axle loading, weight in itself is not undesirable. However, care should be taken to ensure that the limits imposed by the type of permanent way and bridges are not exceeded.

The question of correct adhesion for shunting type locomotives has been investigated by A. O. Helps[3] who gives the following particulars :

Type of Industrial Locomotive	Usual allowance for γ value	Equivalent adhesion lbs/per ton of loco. weight	Adhesion Factor of Locomotive
Steam	.19	425 lbs/ton	5.25
Diesel/Mechanical	.237	530 lbs/ton	4.2
Diesel/Electrical	.26	585 lbs/ton	3.85

Values for columns 2 and 3 should certainly be not much less than those given, else maximum starting tractive effort can never be exploited, especially under extremely poor adhesion conditions due to wheel slip. Conversely, corresponding higher values would indicate uneconomical design weight and lead to pointlessly high axle loadings.

The factor of adhesion is the ratio of the locomotive's gross weight in lbs. and its maximum tractive effort, and this is equal to the reciprocal of the co-efficient of friction, i.e.,

$$\text{T.E.} = \gamma\ W \qquad \text{or A.F.} = \frac{W \times 2240}{\text{T.E.}} = \frac{1}{\gamma}$$

The values obtaining with various weather conditions as given by Molesworth are still usually accepted, and are given below. It will be noted that the variation in adhesion between extremely wet and extremely dry rails respectively is very small.

Weather Conditions	Adhesion, lbs/ton	Corresponding co-efficient of friction or adhesion
Rails very dry	600	.268
Rails very wet	550	.245
Ordinary English weather	450	.2
Misty weather, rails greasy	290	.13
Frosty or snowy weather	200	.09

Further detailed reference to this subject can be obtained from Koffman.[2]

Prime Mover.

A full consideration of the diesel engine is again outside the scope of this paper, and much has been published from time to time on the traction type prime mover. However, suffice it to say that having determined the required continuous rating of the engine, care should be taken to select one with a good record for reliability and low maintenance costs. As in all traction applications, railway diesel engines demand a balance of high order if undesirable vibration and roughness are to be avoided. In general, the magnitude of unbalance decreases with the increase in the number of cylinders. Six and eight cylinder in line 4 stroke engines are inherently balanced, but three, four, five and seven cylinder in line four stroke engines are not. Engines with an odd number of cylinders are therefore usually omitted from a traction range, and four cylinder engines are provided with some form of harmonic balancer to overcome this fundamental disadvantage. One to eight cylinder in line two stroke engines are not inherently balanced and for this and other characteristic reasons are not generally favoured in this country for industrial locomotive application.

In traction type engines, the engine speed must be variable over a wide range. Therefore the problem of torsional vibrations can be very real if steps are not taken to reduce the amplitude of the correspondingly high number of critical points in the speed range, especially those of a low order. This tuning is usually carried out by the fitting of a suitable damper and the viscous fluid type is commonly used in this country. However, natural frequencies and hence critical speeds and their orders can now be so accurately calculated at the design stage, that troubles in this field are almost an exception. Traction engines call for the maximum possible bearing areas, and modern practice is to line the bearings with harder alloys than the normal white metal type. Such alloys as copper lead, lead bronze etc., require harder shaft materials, but a modern development is the use of the thin shell " tri-metal " bearing which has a very thin plating of babbit on a copper lead foundation, and for which satisfactory operation on soft shafts is claimed.

APPENDIX

To show the application of the foregoing data more clearly, Fig. 1 has been prepared to indicate an arbitrary but typical small docks or industrial estate, for which the use of a diesel shunting locomotive is under consideration.

Site Particulars.

For simplicity, only one side of the dock is shown laid out for railway traffic. The only commodity handled is timber, which is taken direct from ship to railway wagons standing on the wharf. These are then hauled in train loads to the timber sheds where the wood is off-loaded and stored. From time to time, train loads are

(2) Adhesion and Friction in Rail Traction, by J. Koffman, see Journal of the Institution of Locomotive Engineers, Vol. 38, No. 205, 1948.

(3) Locomotives for Heavy Dock Shunting. "Dock and Harbour Authority," July 1951.

Diesel Shunting Locomotives—continued

made up at the timber sheds and hauled out of the estate to the small marshalling yards adjacent to the main railway line, prior to long distance despatch.

All curves are indicated on Fig. 1 and it will be noted that between the bridge across the stream and the entrance into the marshalling yard, there is a 1 in 150 gradient, approximately 450-ft. long, coincidental with a 450-ft. radius curve, approximately 750-ft. long. Between the base of the gradient and the marshalling yard entrance, a road crosses the track, which is controlled through hand operated gates.

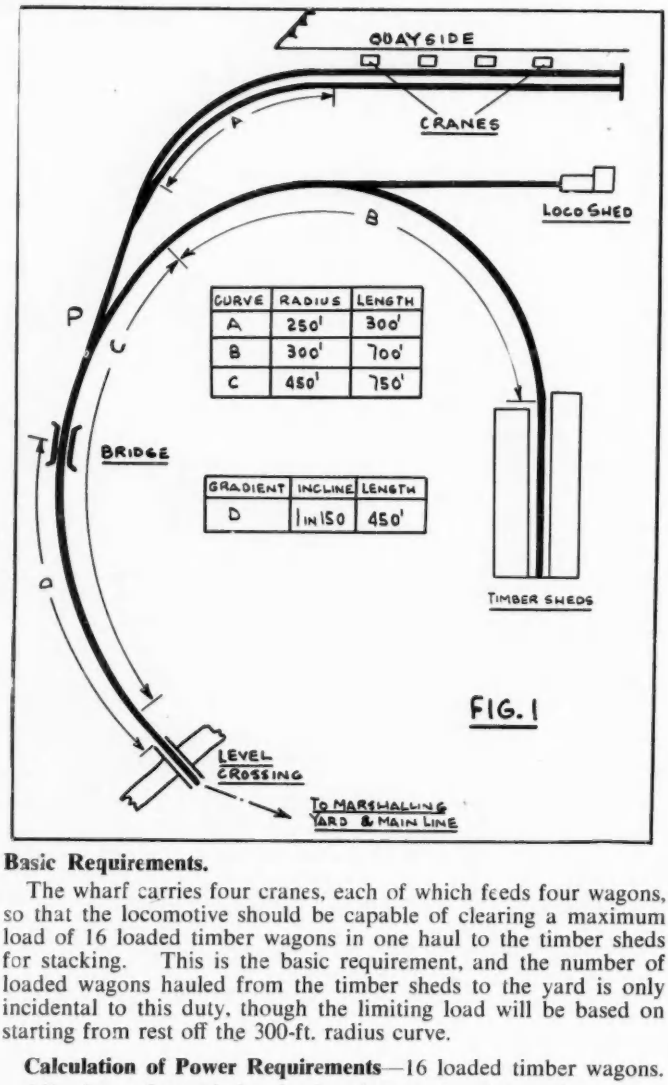


FIG. 1

Basic Requirements.

The wharf carries four cranes, each of which feeds four wagons, so that the locomotive should be capable of clearing a maximum load of 16 loaded timber wagons in one haul to the timber sheds for stacking. This is the basic requirement, and the number of loaded wagons hauled from the timber sheds to the yard is only incidental to this duty, though the limiting load will be based on starting from rest off the 300-ft. radius curve.

Calculation of Power Requirements—16 loaded timber wagons.

Allowing a 5-ton timber load and averaging 6 tons 8 cwt. tare weight for each wagon having oil lubricated axle bearings, the total train load will be (16 × 11.4) plus, say, 20 tons for the weight of the locomotive, equalling 202 tons.

Averaging overall length of Railway Executive wagon at 20-ft. 6-in. ; 20-ft. for locomotive, and allowing coupling stretch between wagons at 1-ft., then total length of train equals 364-ft. The resistances to which the train is, or could possibly be subjected between the wharf and timber sheds, are as under, with reference to Fig. 1.

(1) **Starting train from rest on straight and level track at wharf.**

Starting resistance—18 lbs/ton (oil lubricated axle bearings).

(2) **Running resistance of train round 250-ft. curve A.**

The curve is 300-ft. long; therefore portion of train subject to

$$\text{curve resistance only} = \frac{300}{364} = .825$$

$\therefore$ Curve resistance only by Morrison formula

$$= .825\ \left(2240 \times \frac{D+L}{2\ r} \times f\right)$$

Where D = rail gauge in feet = 4-ft. 8½-in. = 4.7-ft.
L = rigid wheelbase of wagon = 10-ft.
r = curve radius = 250-ft.
f = coefficient of friction = .27

Substituting these values, R_c = 14.5 lbs/ton
Adding rolling resistance R_r at 12 lbs/ton
Gross resistance to motion, $R_c + R_r$ = 26.5 lbs/ton

(3) **Starting train from rest, completely on 250-ft. curve A (should this be necessary).**

From curve particulars (2)
Gross resistance to motion = $R_c + R_s$ = 14.5 + 18 = 32.5 lbs/ton.

(4) **Starting train from rest at Points P.**

Reference to Fig. 1 will indicate that in order to reach the timber sheds, the train must clear Points P and come to rest, before the locomotive can propel forward again. In this position, a start has to be made with the whole train on the 450-ft. curve and 264-ft. of it on the 1 in 150 gradient. The first 100-ft. of the train will be on level but curved track. Resistances to which it will be subjected as as under :

(a) Starting resistance at 18 lbs/ton.

(b) Using the Morrison formula (see 2), a 450-ft. curve resistance of 10 lbs/ton.

(c) Gradient resistance of $\frac{264}{364} \frac{(2240)}{(150)} = 11$ lbs./ton.

Then gross resistance to motion,

$$R_s + R_c + R_g = 18 + 10 + 11 = 39 \text{ lbs./ton.}$$

Of the four resistance conditions examined, case (4) at 39 lbs/ton is obviously the most severe, so that this value must be used to assess the required tractive effort.

Then maximum tractive effort demand = R × N lbs.
Where R = overall resistance = 39 lbs/ton.
N = gross weight of train = 202 tons.
$\therefore$ T.E. required = 39 × 202 = 7,900 lbs.

Assuming a maximum first gear speed of 4 m.p.h. and an overall mechanical efficiency of 85%.

$$\text{Required maximum output of prime mover} = \frac{\text{T.E.} \times \text{M}}{375 \times \text{e}}$$

$$= \frac{375 \times .85}{7{,}900 \times 4} = 99 \text{ BHP}$$

An engine of this rating would permit the load to be hauled up the gradient at a constant speed of 4 m.p.h.

Reference to various types of traction engines marketed will indicate which is the nearest available to this rating. Assume that the engine chosen would give the locomotive a maximum tractive effort of about 8,500 lbs.

Taking a γ value of .2, the corresponding weight of the locomotive should be in the region of

$$W = \frac{\text{T.E.}}{\gamma} = \frac{8{,}500}{.2} = 42{,}500 \text{ lbs.}$$

Say 19 to 20 tons

This would give an adhesive factor of 5 to 1.

Braking on the Incline.

As stated, between the bridge and marshalling yard, there is a gradient, 450-ft. long, coincidental with a 450-ft. radius curve, approximately 750-ft. long. As there is a road crossing with gates at the foot of the incline, obviously, care would have to be exercised in controlling a loaded train, so it is essential for the driver to know what his stopping distance would be for a case of emergency, at a given stated speed.

Assume that a maximum load of say, 200 tons is being taken into the yard at a speed of 4 m.p.h. down the gradient.

Diesel Shunting Locomotives—continued

Assume that the weight of the locomotive is 20 tons, then braking resistance based on 75% adhesive weight and coefficient of friction, brake block to tyre at .22=(.75×20×2240).22=7400 lbs.

Resistances—Whole train on curve and gradient

R_c —450-ft. curve—10 lbs/ton | 19 lbs/ton

R_r 9 lbs/ton

$R_g = \frac{2240}{150} = 15$ lbs/ton, but as the train is proceeding down gradient, it is acting as on acceleration force, so will therefore have negative value.

∴ Total resistance to motion
=7400+220 (19 – 15)=8280 lbs.

$$\therefore \text{Stopping distance} = \frac{78.5WV^2}{R} \text{ ft.}$$

$$= \frac{78.5 \times 220 \times 4^2}{8280}$$

$$= 33\text{-ft.}$$

This value represents the stopping distance for a train of stated load and under stated grade and curve condition, travelling at 4 m.p.h. at the time of brake application, with all wagon brakes off.

In conclusion, it is hoped that the foregoing will illustrate the importance of dealing with each traction problem entirely on its own merits. This is fundamental if the right locomotive for the job is to be obtained. For obvious reasons, not every industrial site can be analysed so exactly as the example given in this paper. On larger docks especially, train loads often comprise wagons of different tare and capacity containing various commodities, so therefore a good all round average "gross weight of wagon" must be taken when calculating the loading schedule for "mixed goods" trains. Again, on large estates (say about 100 miles and over), a compromise must be taken when assessing starting resistances in order to formulate a load schedule. The writer uses a value based "half on and half off of 300-ft. curve" for this purpose. The starting and rolling resistances given should not be taken as exact to the nearest lb/ton as these values depend on such variables as type and condition of vehicles and permanent way; the latter, of course, can differ considerably from site to site. However, the values stated are considered to be fairly representative for most industrial estates where the track is never up to main line standards and they can, therefore, be used with reasonable accuracy. Where a number of different but individual commodities are handled in set loads, such as timber, oil (tank cars) as well as general mixed traffic, the operator is advised to formulate a schedule for the maximum number of loaded and empty vehicles which may be hauled by the locomotive, based on its maximum tractive effort and the track resistance characteristics. If a printed copy of this is posted in the cab of each locomotive and the drivers made responsible to maintain these limits, the locomotive can be worked up to its full capacity without fear of overloading.

Model Research on Harbour Problems

Hydraulic Investigations at Wallingford

By A. G. THOMSON.

In designing large coastal engineering projects such as harbours, difficulties are often presented by the absence of any reliable method of estimating the effect of the proposed works on the continual interaction of loose boundary and flowing water. The engineer can only be guided by past experience and intuition as to what the eventual configuration of a bed or channel may be. No less incalculable are the strength and distribution of the currents set up by given wind conditions and other factors, and the destructive effects of breaking waves.

Due to the complex factors governing hydraulic behaviour, a harbour may act in an unforseen manner and prove to be unsafe during particular conditions of wind and tide, or unexpected excessive silting problems may be presented. It sometimes becomes necessary to build costly breakwaters or carry out other major modifications in order to overcome the consequences of a design which has proved unsatisfactory for reasons which could not be foreseen. In the United States and in various Continental countries experimental tests with models are therefore undertaken as standard practice when hydraulic projects involving large expenditure are under consideration.

For many years civil engineering firms in the United Kingdom were at a disadvantage because there was no national research centre to which they could apply for expert guidance on specific problems. To meet this gap in Britain's research facilities a Hydraulics Research Board was established in December, 1946, and Sir Claude Inglis, C.I.E., F.R.S., was appointed Director of Hydraulic Research. After a long search for a suitable site a property comprising some 90 acres with a large house was acquired at Howbery Park, near Wallingford, Berkshire, on the left bank of the river Thames. Here a research station is rapidly taking shape, and an expanding programme is being carried out.

The present facilities at Howbery Park include two wave basins, each 120-ft. long by 80-ft. wide and 2-ft. 6-in. deep. No. 1 Basin is used for the investigation of problems involving waves and tides.

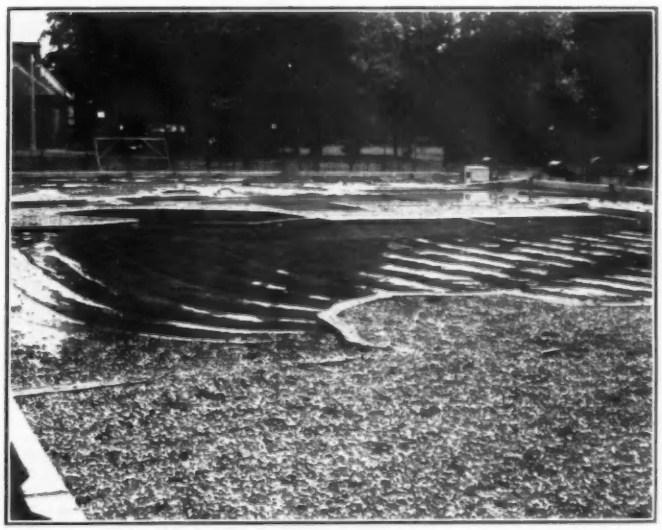


Fig. 1. Model of Lyttleton Harbour.

Waves are made by paddles which can be orientated in various directions and tides by a constant output from a pump and an overflow over a variable weir. No. 2 Basin, as well as having tidal and wave generating mechanisms, has been equipped with a large reversible circulating pump capable of deliverying tidal currents up to 65 cusecs in both directions.

Two models of Lyttleton Harbour in New Zealand were constructed in No. 1 basin. One was a model of the whole tidal inlet to scales of 1/600 horizontally and 1/100 vertically. It could be used either as a rigid bed model to study the disturbance caused by very long waves or as a moving bed for research on silting. The second model had a rigid bed and reproduced the neighbourhood of the inner harbour to scales of 1/180 horizontally and 1/90 vertically (Fig. 1).

The purpose of these studies was to assess the relative merits of different designs of extensions to the existing harbour from the point of view of the protection they afford, their susceptibility to ranging, and the amount of dredging required to keep the harbour open.

Model Research on Harbour Problems—continued

A wave model for investigating the behaviour of the projected harbour at Tema in the Gold Coast is now being constructed in No. 1 Wave Besin to a horizontal scale of 1 : 120. This harbour is being built for the Gold Coast Government, the Consultants being Sir Wm. Halcrow and Partners, and is being carried out in three stages. The first stage will consist of a single finger berth and the second stage of three finger berths. In the third stage some land on the site of the present beach will be reclaimed. The objective of the model investigation is to ensure that the harbour is adequately protected both from ordinary wave action and ranging. The present design of harbour will be studied and subsequently the effects of shortening the breakwaters and of other modifications will be examined.

The prototype breakwaters will be constructed of large blocks of locally hewn stone and will be subjected to severe wave action. Their behaviour under storm conditions has been studied on a model of a typical section of the breakwater built to an undistorted scale of 1/40. After various modifications of the original design had been tested, it was discovered how the large rocks should be arranged and graded so that they will be undisturbed by the largest waves. This successful design has been accepted.

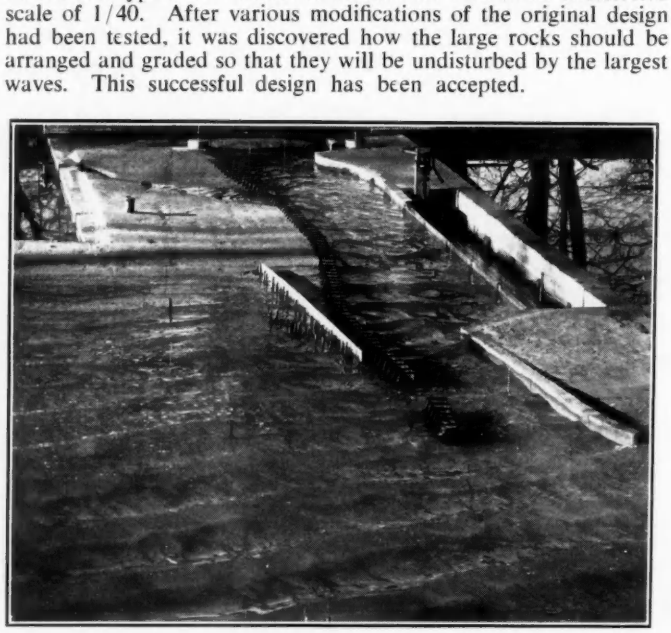


Fig. 2. A mobile-bed model of the entrance to Southwold Harbour, which has provided valuable information on the model-to-nature relationship in three-dimensional model investigations concerned with littoral drift and the equilibrium of beaches. It has also given useful results on wave conditions inside the harbour.

This work was carried out in a wave tank 54-ft. long by 10-ft. wide, with retaining walls 3-ft. high. In this tank it is possible to reproduce waves and tides and to vary the shapes of waves. An investigation has been carried out to determine how the rate at which water particles drift in the presence of waves varies with depth. This preliminary work was followed by experiments undertaken to study the effect of adding a vertical wall at the crest of a beach that was initially stable. Further experiments are in progress to determine the effect of a permeable obstacle, such as a jetty, placed in front of a beach.

A wind-wave channel 185-ft. long and 4-ft. wide is now under construction. It will be used, *inter alia*, to investigate the effect of wind on wave propagation.

The facilities for research were greatly augmented early this year by the completion of the first stage of the Main Hall, which has made a floor area of 300-ft. x 200-ft. available for model studies. Storage and measuring channels are provided round the whole of the building, as well as a run-off channel draining into the Thames. This large building will eventually be extended by another 100-ft. in each of three directions.

A section of the Main Hall will be occupied by a model of the Karnafuli River from the sea to its junction with the Halda River, some 20 miles upstream. Chittagong is being developed as the main port of East Pakistan, but conditions in the river require to be improved. There are two main problems to be investigated. Where the Karnafuli River flows into the Bay of Bengal the depth of water over the outer bar must be increased. Secondly, in the tidal reaches at and immediately above Chittagong the rapid fluctuation of the channel meanders must be stopped and the channel position must be stabilised alongside the shipping jetties. These problems will be studied in a large mobile-bed model which will have a horizontal scale of 1/500 and an overall length of approximately 200-ft.

Because of the importance of instrumentation in hydraulics research, the instrument and electronic sections at Howbery Park are very strong. Among the instruments they have developed are miniature current meters of novel design, recording tide gauges for use in models, wave height analysers, and equipment for recording the shapes of waves.

Howbery Park is also provided with a specially equipped sedimentation laboratory for studying sands and silts, important to the operation of mobile bed models. There is a carpenter's shop where models and components of models are constructed, and a metals workshop fully equipped for all types of precision work.

It is evident that this research station, manned by a highly trained and experienced team and provided with facilities for large-scale model studies under precisely controlled conditions, will be playing an invaluable part in solving problems associated with the construction of new ports, harbours and jetties, or with the extension of existing port facilities. New light is also being thrown on many difficult problems encountered in coastal engineering by fundamental work at Howbery Park, which is helping to place loose boundary hydraulics on a sounder basis of physical theory.

Permanent International Association of Navigation Congresses

Annual Report of the British National Committee

The period under review in this report is June, 1954, to November, 1955, instead of June to June as normally. This change is a consequence of the adoption, at the July, 1955, Annual General Meeting, of the new Regulations to supersede the previous Constitution. Under these Regulations the Annual General Meeting will in future normally be held in November each year.

As already anounced the XIXth Congress will be held in London in the fortnight commencing July 8, 1957. At the last Annual General Meeting in July, 1955, the formation of a British Organising Committee was reported.

This Committee, under the Chairmanship of Sir Arthur Whitaker, has appointed four sub-committees (General Purposes; Finance; Reception, Visits and Hospitality, and Ladies), to which the formulation of the detailed programme has been entrusted. These sub-committees have each had several meetings in the past few months. Particulars of the meetings are not yet available, but, in general, the programme will comprise, in the first week, technical sessions and visits and excursions in or near London and in the second week, visits and excursions to works and places of interest further afield.

The Special Committee on Depths in Seaports has completed its work and the Report has been sent to Brussels. It is hoped that it will appear in the next issue of the Bulletin.

While the British National Committee is not yet satisfied that the membership is consonant with the size of this country's maritime interests, they have noted that there has been an increase. The present membership figures are: Life Members 26, Corporation Members 18, Private Members 50, Total 94 as against 62 last year.

The British National Committee again desire to impress on members the necessity of still further increasing the membership of the British Section, particularly because London has been selected as the venue for the next Congress.

Problems of Port Equipment

Cargo Handling Experiments at Marseilles

By L. FELINE
(Chief Marine Engineer, Director of Equipment and Dry Docks, Marseilles).
(Translated from the French).

THE construction of a maritime port is the fruit of extensive experience; it represents the sum total of knowledge and of judgment of people of diverse qualities, such as seafarers, merchants and engineers. But, as in many other walks of life, experience is by itself not enough; consequently the problems of a port can only be solved by considering anew the concept of a commercial port and by making a fresh study of the handling of merchandise from hold to warehouse.

There is no doubt that when the majority of the world's ports were built the importance of adequate ground space and its effect on port development was understood. However, the engineers responsible for port construction did not always envisage their works on a scale suitable to the present day, either through lack of money or through failure to foresee probable developments.

The complete upset in calculations which was to be caused by the advent of steamships with their larger cargoes, quicker turn-round and reduced maintenance time was not immediately apparent. As a result the wharves were originally planned with neither enough space nor the necessary traffic facilities.

In order to illustrate the need for spacious amenities it is enough to quote some figures which were given at a conference on maritime ports in London in 1950:

Tonnage of Cargo	Equivalent length of Ship (metres)	Quay length per 1000 tons loading (metres)
4,000	88	22
10,000	140	14
25,000	220	8:8

This means that in order to discharge 1,000 tons from a ten thousand ton ship there is required a breadth of quay 1.6 times bigger than for a 4,000 ton ship, and that to discharge the same cargo from a 25,000 ton ship the quay breadth must be 2.6 times greater.

In order to meet such a requirement, it is necessary either to enlarge the aprons, and sheds in the same proportions, or to speed up the handling of goods during the actual discharge.

It is not always possible to enlarge the quays or to make large areas available behind them, and in any case the scattering of merchandise over these areas would create handling problems. It is therefore only by improvements in the lifting of goods, that is to say by organising the handling, that the solution must be found.

It must be stated that the increase in ships' tonnage is dictated by economics. The density of cargo is greater in a large ship than in a small one, while the operating cost does not increase in proportion to the bulk carried. Thus from the revenue angle it pays to increase ships' tonnage, and the tendency to do so is checked only by market limitations and inadequate port installations. Where these limitations do not exist, as in the case of the great modern oil ports, a continuous increase in tonnage is to be seen.

There are no particular technical difficulties to be encountered in the development of ports, as regards construction of quays, the enlargement of aprons and sheds; these are works which are well understood. The most difficult problems which lie before us are those of cargo handling and rapid ship repairs.

Limitations on Handling Equipment.

It is no exaggeration to say that up to the last war the most important operation in the discharging of a ship was that of taking the goods out through the hatch and putting it on the quay. The dispersal of goods on the quay and its stowage in the shed presented no great problems, and the methods in vogue were simple, not to say rudimentary. The same was also true of the operations of stowage and breaking out of cargo which was nearly always done by hand.

When the American troops were faced in 1944 and 1945 with heavy disembarkations at damaged ports, and with solving the problem of stock-piling over considerable areas, they showed great interest in mechanical handling at the quayside. Some of them even thought that the small mobile apparatus which had then just made its appearance, and in particular the fork-lift truck, would solve all handling problems. They even began to doubt the necessity of quayside cranes, and in the same breath they thought that derricks would suffice and that it was possible to avoid altogether costly investments in port equipment.

Their infatuation with these ideas was due on the one hand to the remarkable performance of mobile equipment, and on the other hand to the fact that the cranes built in those days were massive and costly, and showed a poor output when performing the same duties as a derrick. Indeed, on account of the mobile equipment and of facilities available for unstowing, the derrick loads were light, and were mostly less than 2 tons.

Now the cranes of the day had a lift of at least three tons, not to mention their ability to discharge quite a large package anywhere on a large area of quayside. But this capacity was at a discount compared with the immediate requirement which was to discharge a light load close alongside, a requirement which could be met by simple equipment such as the derrick.

But it must be said that the experienced which was gained at Marseilles in 1945 showed that the quayside crane of classic pattern, when quick and easy to handle, could follow the rhythm of the other equipment in use on shore, and that the results of the combination of the two sets of equipment was extremely interesting. The crane in the end completely took the place of the derrick.

The quayside crane then, is by no means condemned, far from it, but it is as well to re-examine both its characteristics and its construction. Indeed one should go further and consider the whole problem, while making a more exact appraisal of the part played by different pieces of equipment. To give an example, the fact that the vast majority of the loads are less than two tons is not the result of using either crane or derrick, nor is it caused by the use of mobile equipment. It is caused by stowage difficulties in the hold. Thus one must review the whole question from the beginning.

Stowage in the Hold.

The handling of goods in the hold is often inconvenient, and the output is poor. Access to the tweendecks and holds is usually made difficult by the relative narrowness of the hatches. Some means of transporting goods is just as necessary here as elsewhere. The lack of head room in the tweendecks makes it difficult if not impossible to make use of handling gear. Conditions are easier in the hold itself but only where there is no obstacle to traffic. When it comes to the handling of large packages, work in the hold becomes still more onerous and it is certainly this difficulty which puts a brake on the development of containers.

The fork-lift truck has been tried out, but it has not given the service which one would have expected of it. This is chiefly on account of the way it has been conceived. Tractors on the other hand need room to move, and do not solve the problem of stacking. Thus they do not make for anything like the density of stowage which can be achieved by manual work. Now it is essential to solve this problem which seems to be the most crucial one at the present time. To do this one must first construct holds which are large and of easy access. Secondly, one must design a special item of gear for handling goods in the hold, and thirdly one must provide fixed handling gear in the holds.

These three requirements have been studied, and some interesting experience has resulted. So far as the arrangement of hold

Problems of Port Equipment—continued

is concerned it will be appropriate to draw attention to two recent achievements. A new type of cargo vessel has been built by Canada Steam Ship Lines, in which the engine room is sited aft, while the three holds are placed forward. The holds are served by intercommunicating doors which have been cut in the watertight bulkheads. Above the holds is a huge tweendecks with no obstacles. There are two three-ton electric hoists capable of carrying a fork-lift truck or tractor, and these hoists communicate with the hold, the tweendecks and the main deck. The ship is also equipped with wide hatches and with three wide cargo doors placed in line with the centre of each hold (see Fig. 1).

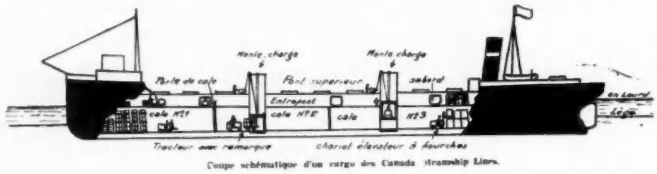


Fig. 1.

A Danish Company has advanced this idea a stage further by making a study of a type of ship in which engines and accommodation are also concentrated aft, but in which the essential feature of the ship is a single large hatchway extending all the way from the engine room to the forecastle. Since the ship in question is not used for extensive voyages it has even been possible to provide two electric cranes which run on rails formed by the longitudinal members of the hatch coaming (Fig. 2).

These studies of ship arrangement are matters to which we would like to see all naval architects give some attention. Along the same lines there are also to be considered some developments which originate in small handling gear. It seems certain that it should now be possible to evolve an apparatus of the free-lift fork type which would be underslung—without taking up room—from runners near the deck-head. Such an apparatus should facilitate handling and stowage of packages and loads.

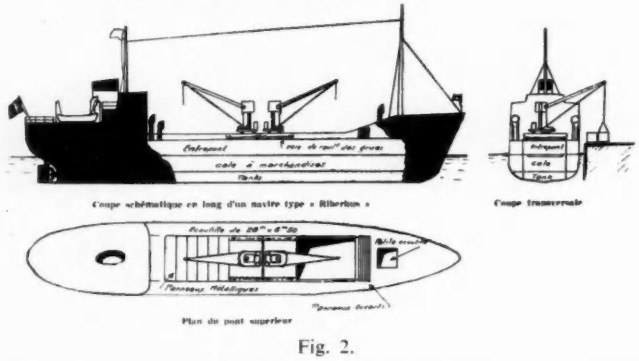

Entrepont
cale à marchandises
Coupe schématique en long d'un navire type « Riberhus »
Coupe transversale
Plan du pont supérieur

Fig. 2.

But all these items of fixed or mobile equipment can only exert a limited effect; besides handling of goods in the hold in the end depends on the stowage of small packages, if a good return is to be secured. One may cite the example given by furniture removers; a novice will always make his packages too big, while the professional will make the same goods into a number of smaller bundles.

Handling on the Quay and Stockpiling in the Sheds.

This side of cargo handling has without doubt made the most progress, and nearly all requirements are met by mobile equipment. The dispersal of goods from the places where it has been dumped by crane or derrick is achieved by tractor or fork-lift truck. Stackage in the sheds is done by elevators and mobile cranes, or, in the case of those important items bagged and case goods by means of a roller conveyor. Here the problem rests solely on the construction of strong, simple and economical machinery. It will be convenient at this point to draw attention to the research and experiment which has been carried out on electrically driven machinery.

The power of a piece of mobile equipment is a function of the load it has to handle. Where handling is done in a ship's hold it is stowage rather than transport which dictates the size of the load. The latter is also limited by the handling gear itself which must be light and easily handled. In fact, one discovers afresh that the commonest loads are here less than two tons.

Loading and Discharge of Goods.

When steamships first came on the scene, it seemed that the quayside crane would be the ideal machine for loading and discharging. But ship dimensions increased, and that meant cranes with greater reach and hoist. Then the need to speed up the rate of discharge brought about an increase in loads and in speed of lift (see Fig. 3.) In consequence the quayside crane which began by being a well thought out piece of machinery, is now being called upon to do jobs for which it was never designed, and it must be said that unfortunately these changes have not been well considered. There has been too much strengthening of cranes without reviewing the whole problem.

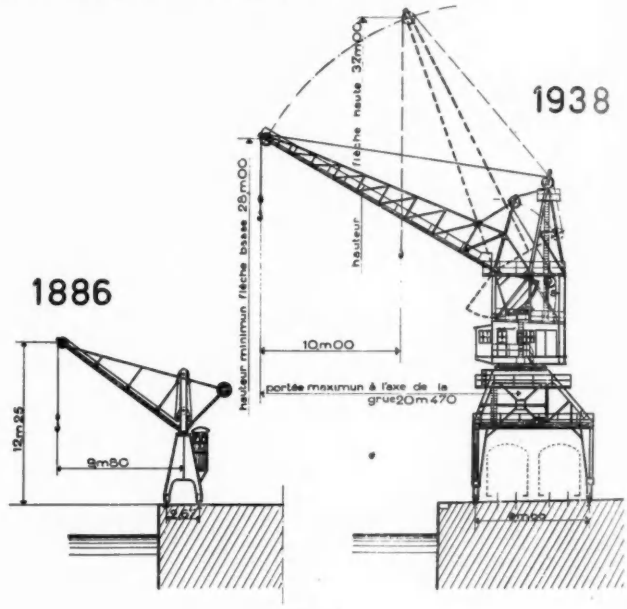


Fig. 3.

We have just seen that the most handy weight for a load for handling in the hold or for stowage in the shed is less than two tons. There are two ways in which a ship can be discharged to best advantage. One is to discharge in a large number of small loads at high speed; the other is to build up large loads under the hatch for discharge at slow speed. The same applies to the transport of goods from the quay to the place where they are to be stacked or loaded into a ship. In actual fact the loads handled by crane are either light loads, of two tons or less (and they then correspond to the size of load for handling in hold or shed)—or heavier loads, of 4 to 6 tons; these correspond to a grouping of small loads, or to heavy indivisible packages, principally containers.

We have also seen that mobile equipment serves to reduce to a great extent the need for using a wide strip of quayside, and that is what explains the fresh interest in derricks.

In the first instance, the crane must limit its usefulness to lifting goods from the hold and to setting them down, not as hitherto all over the quay but in a narrow belt, and even in a straight line. It is then quite possible that within limits one can find apparatus much less costly than a crane but with a high efficiency and considerable output.

In the second case, that of handling large loads, the crane must be able to either carry out delicate manoeuvres or to handle heavy loads with flexibility and precision.

It seems that in the latter case speed is not the primary consideration; indeed it may even be an inconvenience. In any case

Problems of Port Equipment—continued

if the crane has to have a great lifting capacity its speed will perforce be reduced.

The same winding gear with the same motor can act more quickly with light loads by means of a simple gear change, and in this way the same crane could be used for rapid handling of light packages.

The difference in cost between a single and double geared crane is quite small, and concerns mainly the reinforcement of the framework. Experience has already confirmed that two gears are worth while, but this would have been even more obvious if the choice of gears had been more fortunate. We shall see below that we have come to the conclusion that the most interesting type of crane is one with a lift of 2 tons and a minimum speed of 1.5 to 1.8 metres per second, equipped with a second gear capable of lifting 6 tons at 0.5 to 0.6 metres per second.

As regards simple gear for the first purpose, it must be possible to perfect light gantries carrying folding jibs which extend over the ships and which allow a come-and-go movement to the trolleys supporting a hook whose lift would be determined by the winches at the gantry.

The sole moving element would then be a simple lightweight carriage. The considerable dynamic stresses caused in the conventional crane by sudden stoppages of heavy weights in motion would be almost eliminated. The frame of the gantry and jib could thus be considerably reduced in weight.

As regards the second case, to permit full range of movement the crane must remain able to rotate and to luff the jib, i.e. it must keep its original structure. But if it is not to be prohibitively dear and too much of a charge on the cost of handling, and if at the same time it is desired to use the same crane for light loads, it is important that it should be re-examined and improved.

To begin with the whole idea of framework and jib must be reviewed. To lighten these parts is imperative, both to cut the cost and to reduce inertia of rotation, and hence to reduce irregular stresses on frame and machinery.

Lightness cannot be achieved, as it has too often been done, by increasing the loading on the metal, but by a systematic investigation into the reduction of useless counter weights and into a better distribution of stresses.

We have always urged that cranes must be robust, simple, and with a minimum of articulation, and that they should work, so far as stresses are concerned, under optimum conditions. The classical concept of cranes with their rotating parts offering considerable inertia to being turned, leads to considerable inertia stresses on the framework while they are being luffed and rotated. These stresses are not well defined, and they cause the crane to work under very faulty conditions. Besides, in spite of the fact that the rotating part is balanced, these stresses are transmitted via the turntable to the gantry, and the latter is subjected to a very real torque. One only has to determine the vibrations which occur both in the gantry and the jib, at the moment when rotary movement ceases, to realise how important these stresses are.

We must be able to apply a remedy for these troubles by regrouping the mass of the crane round its axis of rotation, as was done in the case of some old hydraulic cranes. The best solution for this is the central pivoting shaft, which allows of a decrease in the moment of inertia of the rotating part by abolishing counterweights. The stresses caused by a change in direction of rotation are obviously transmitted to the gantry, but these stresses are better understood, and their point of application is more definite. Also the gantry can be made heavier and stronger without any trouble because it does not itself have to undergo accelerating movements.

New Equipment in the Port of Marseilles.

Our comments on cranes are the outcome of experience in the use of equipment at Marseilles. This experience has shown us the need for avoiding apparatus which is fragile or easily put out of order, and the importance of studying designs which allow of easy dismantling. We have also learned the importance of looking for the answers in terms of simple electrical equipment. However, all the port engineers have come to the same conclusion, namely, that in the development of the right conditions for using cranes our experience has perhaps been more complete than in other ports.

The Port of Marseilles was in fact one of the first in Europe to use fork-lift trucks and tractors, and at the present time it is still the leading European port as regards mobile equipment, with 140 fork-lift trucks and about 75,000 pallets.

At the time of the Liberation there were hardly any cranes in the port, and ships were discharged by means of derricks, as in the great American ports. Re-equipment began with those cranes which could be repaired, namely those at the Joliette Basin, which had been specially designed prior to 1939 for the unloading of early vegetables. They were three ton cranes, very manoeuvrable and with a quick lift. The first new cranes ordered for the reconstruction were cranes of the same type, and it soon became certain that if these cranes were more powerful than was necessary, their speed was at any rate well adapted to the new handling conditions. If they had been less quick and easy to handle they would perhaps not have ousted the derrick so quickly and easily.

But if from the technical viewpoint, our experience at Marseilles was successful it is because we used not only fast cranes but cranes with a good output. Here we come to the crux of the matter. We have seen that the best output is secured in hold or in shed with small loads, but that is not so obvious during the acts of discharging and transport on the quay. Some people even reckon that although the making up of heavy loads under the hatch causes a loss of valuable time, the lifting by crane and transport on quayside of large loads gives a good return. There is no doubt that this is so, but unfortunately people forget to add " so long as the speeds are maintained, or at least are not allowed to fall off too much."

Now, the cost of handling machinery, both capital and maintenance goes up steeply when one increases the number of things it can do. The importance of our experience at Marseilles is that we have been able to show the optimum value for these characteristics.

A piece of handling machinery and particularly a crane cannot be classified only on its lifting power. One must at least show also its speed of lift. But if we take an expression such as Lift x Speed = Constant, we end up with a figure which defines the winding gear, or if need be the crane itself.

The output, in theory, at least, increases in proportion to this constant, but it is not the same with the first cost and maintenance. These increase more rapidly, and our experience has shown that an increase in the constant brings mechanical and electrical complications in its train which are out of all proportion to the output.

The cranes at Marseilles, of the type Applevage, built before 1939, had a lift of three tons and a minimum speed of 1.5 metres/sec.; they were excellent cranes. Their constant, 4.5 ton/metres appears to be the limit. We know of other cranes with a constant in excess of this limit, but they are not easy to handle or to maintain. On the other hand we know of a number of ports with cranes of a much lower constant, where the operators are very pleased with their sturdiness. This idea of a constant " force times speed " seems also applicable to hoists and tractors.

As regards cranes, the constant of 4.5 ton/metres calls for motors of not more than 75 horse power. The starting load does not exceed 250 amps on three phase 400 volt mains. Thus the motors, starting gear and cables all fall within the limits of present-day industrial equipment. But this is a constant limiting factor.

We even consider that it would be worth while having less powerful motors, and we have accordingly selected for our future cranes a constant of 3.6 ton/metres, which corresponds to a hoisting motor of 60/65 horse power.

We have sought for the future characteristics of our machinery within this equation—Force × Speed equals 3.6 ton/metres. As stated above, we arrived at the notion of using cranes with two gears, for rapid handling of light loads and for lifting heavy loads with accuracy. Our experience in recent years during which mobile equipment has been increased in Marseilles leads us to conclude that we must adopt cranes with a double lift of two tons at 1.8 metres/sec., and 6 tons at 0.6 metres/sec.

Indeed, seventy-five per cent. of the loads are less than two tons. When we use three ton cranes for these loads, they are being shifted at the speed appropriate to a three ton load, which is a lower speed than could be secured even by lowering the constant of the cranes. To be sure, by lowering the limit from three to

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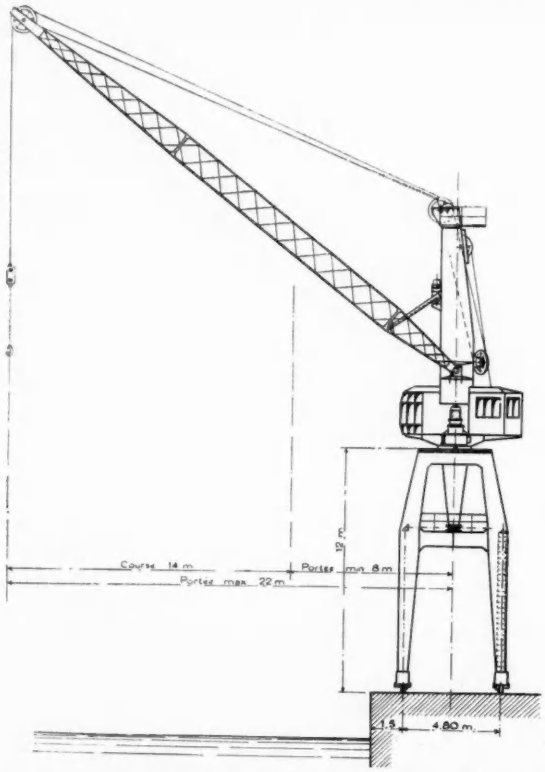

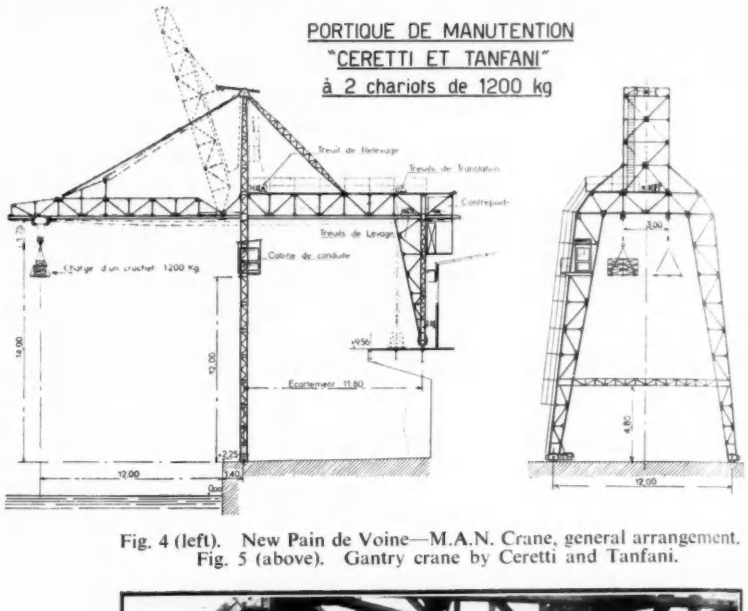

Fig. 4 (left). New Pain de Voine—M.A.N. Crane, general arrangement.
Fig. 5 (above). Gantry crane by Ceretti and Tanfani.

two tons, we impose a condition of slow handling, at the 6 tons rate, on all loads between two and three tons, but to compensate for this we get 75 per cent. of the loads shifted at 1.8 metres/sec. Loads between two and three tons are relatively scarce, round about 10 per cent., so that the result is an overall improvement in output, despite the less powerful winding gear.

It is on these considerations that we placed orders for the new cranes at Marseilles (Fig. 4), and these will satisfy all the mechanical and electrical conditions which we have postulated above.

A New Travelling Gantry Crane.

Simultaneously with the compilation of data regarding our new cranes, we have developed and put into action a much simpler piece of equipment which conforms to all the conditions which we have already laid down.

This is a travelling gantry crane which we have built with the help of Ceretti & Tanfani. It was created to make the best use of the sheds at Joliette Basin where the bulk of the early vegetable traffic is handled (Fig. 5). The weight of loads was fixed at 1.200 kilos with a minimum speed of 1 metre/sec. The constant is therefore 1.2 ton/metres, which results in the use of simple winding gear and motors of about 30 h.p. We chose this low constant in order to make use of mass produced materials, and to simplify the electrical equipment, and, in order not to diminish the output unduly, we designed the crane with two sets of winding gear.

The gantry has two parallel lines of motion (Fig. 6) whose importance was immediately made plain at the trials. The dockers in the hold can get a second load ready while the first one is being raised, and while one hook is setting its load down on the quay the other is being lowered into the hold. Thus we get an increase in discharge speed without speeding up the conveyor. Besides, we find that for the given constant the output of a gantry is superior to that of a crane. Other advantages consist in the elimination of delicate movements of rotation, and general simplification of the total process of lifting and conveying goods, requiring less vigilance and subject to less risk of damage. Again, the total distance travelled by a load is less than it would be if a crane were used, so that despite the lower hoisting speed the total transit time per load is less.

A further advantage lies in the fact that the trolley has much less inertia than the rotating crane, and is able to accelerate and slow down more rapidly, an important consideration in short hoists.

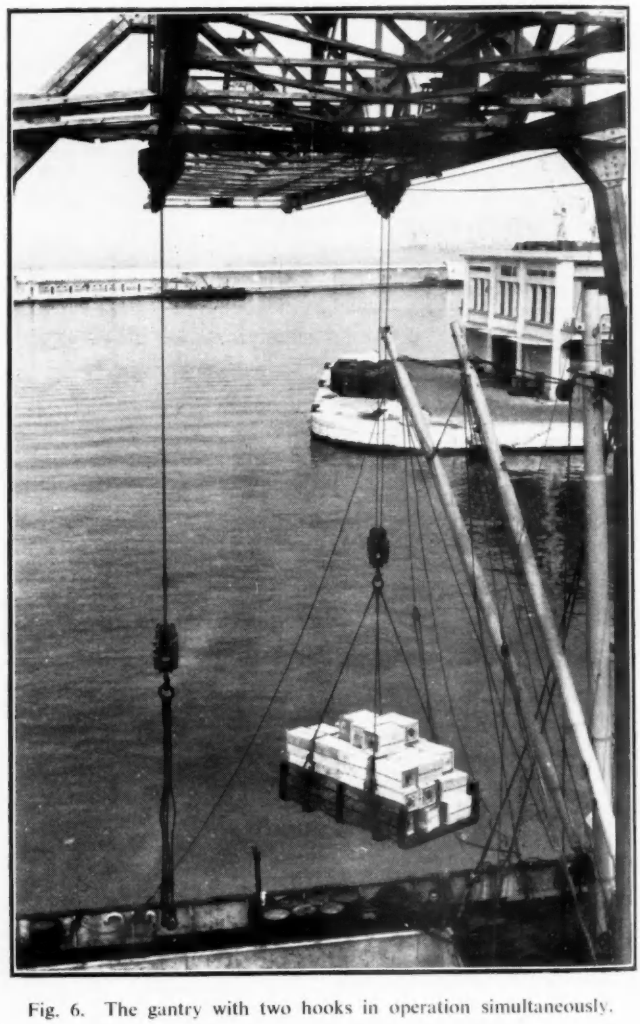

Fig. 6. The gantry with two hooks in operation simultaneously.

The first trials of this gantry have confirmed these ideas, and it has been found that despite the fact that the sum of the constants

Problems of Port Equipment—continued

of the two sets of winding gear was less than that of a crane, the gantry with its double hoist and conveyor has handled as many loads in the hour as the crane.

The gantry is quite light, not more than 30 tons, but nevertheless the loading on the frame is no more than 10 kilos per m/m^2. This shows again the importance of getting rid of inertia, and of avoiding heavy masses in motion. The only moving parts are the two trolleys; the winding gear is located at the rear of the crane. At first we had considered having the winding gear integral with the trolley, but the combination was too heavy and would have compelled us to have a very heavy frame for the outer wing of the gantry.

The trolley is moved by a wire rope which is driven by a drum at the back of the gantry. This has proved satisfactory in trials, but it calls for a double length of wire rope running above the hoist rope. We have tried out a variant, by fixing an independent motor on one of the trolleys but the final solution is a matter for experiment.

The portal runs on rails (Fig. 7) and the track is 11.8 metres. The greatest reach is 14 metres outboard of the quay, and there is also a 14 metre clearance under the hook.

Fig. 7. Showing the wide track of the Portal.

The electric motors are asynchronous, of a standard pattern. The hoist motor is 30 h.p. with time-switch starting gear. The trolley and gantry-raising motors are 6 h.p., while the unit for shifting the entire crane is 9 h.p. The space between the trolley rails is 3 metres. This, we find, is enough to prevent collision of two loads even when they are palletised. This clearance gives a good service to the holds, since hatchways are seldom less than 4.5 metres across.

Control of winding gear and trolleys is normally carried out from a cabin about 12 metres above the quay. But by the aid of a simple switching device the operation can be controlled even from the bridge of the ship, using a set of press-button switches. By this means an ordinary charge hand can control the raising or lowering of the load within the hold, and unlike a crane driver, he can keep the load constantly in view. Thus the output is much improved, while the risk of accidents is greatly reduced. The safety afforded by the gantry, even when operated by ordinary dockers is much superior to that of a crane.

Lastly the whole apparatus is very simple in construction. If the gantries were mass produced, their price should not be more than half that of a crane. But mechanical and electrical simplicity is hard to come by and we have found ourselves driven, together with Ceretti and Tanfani, to make several revisions in the design of framework, machinery and electrical equipment. As it stands the gantry crane must be capable of improvement.

The layout of the framework has been retarded by the need to make a choice among existing sections. The motors were also chosen from the standard range. Consequently the frame and winding gear can certainly take bigger loads than those for which it was designed. We are therefore re-calculating the possibilities of a gantry, principally in order to see whether it can be made to work at a load of 1.5 instead of 1.2 tons. But if we went beyond this we should again fall into just those mistakes which we have condemned. The answer is only of interest so long as the gantry stays light and uncomplicated.

We do not think we have found the perfect answer, nor do we consider that the above considerations can of themselves provide the answer to the problem of cranes and quayside equipment. Perhaps, however, they will be of interest to port engineers, and will open the doors to further discussion. In this way a small contribution will have been made to resolving the pressing problem of cargo handling.

Breakwater Damage at Genoa

A Review of Published Opinions

By C. H. DOBBIE, B.Sc., M.I.C.E., F.G.S.

The recent articles in "The Dock and Harbour Authority" on the failure of the Genoa Breakwater by D'Arrigo[1], Grimaldi[2] and Minikin[3], together with a letter by Larras[4], contain many points of general interest. In this article it is proposed to comment only on the interaction of waves and structures.

In the first place there is a not uncommon idea that a breakwater or sea wall should, by use of a fancy shaped coping, return and reflect waves rather than have the wave energy destroyed at the structure. The appeal of an elegant mathematical shape is irresistible but, as is so often the case, illusory. Practical designs achieve reflection only spasmodically, and this is truly fortunate. High vertical walls rising out of deep water do achieve reflection.

The Committee of authors of papers who were given the task of drawing conclusions on this matter at the XVIIIth International Navigation Congress in Rome in 1953, and of which the author was a member, were under no illusions regarding the dangers inherent in this type of design, and were most careful to qualify their conclusions. They said that reflecting breakwaters would succeed only where the minimum depth of water was one and a half times, and preferably twice, the wave height. Also the sea bed in front of the structure had to be stable against erosion although it was possible to substitute extensive apron works. The combination of partial reflection and energy dissipation at the structure was dangerous and definitely to be avoided.

The combination of reflected and oncoming waves creates clapotis, and Sainflou has shown that in clapotis the waves are twice the original height and consequently have great erosive power. D'Arrigo sums up the experience of past failures with the reminder that "the free reflection from the vertical face is a delicate experiment in nature not devoid of peril."

A novel point made by D'Arrigo is the possibility of a geohydrological wave break, causing breaking of waves immediately in front of the structure. By a geohydrological wave break, he means a break caused not only by shallowness but also by the rupture of the orbital motion of the waves resulting from interference by marine currents or by submarine springs of fresh water. An analogy is made with pneumatic breakwaters. D'Arrigo says that Albini discovered in the marine depths of the Gulf of Genoa clearly defined submerged valleys. The profile of the submerged valley coincided with the prolongation over the littoral platform of the gorge of the torrential River Polcevera. This river which enters the sea near the west end of the breakwater is almost dry in summer, but is subject to torrential floods which could possibly reactivate submarine springs and thus cause the geohydrological break.

This is an interesting speculation which certainly deserves a detailed examination. The Admiralty Chart (No. 1461, Approaches to Genoa) shows no sign of a drowned continuation of the Torrente Polcevera, but in any case one would expect the submerged valley to be filled with littoral material. Presumably the torrent could still re-activate marine springs, but only with considerably friction losses. The general area of Genoa is full of fractured limestone and marine springs are quite likely to exist and to be affected by torrential rain inland. Again friction losses must be very considerable. It should be noted in passing that these conditions, i.e.

Breakwater Damage at Genoa—continued

fractured limestone, are far from ideal as foundations for sea defence works.

It seemed to the writer that the quantity of water from such sources would be quite insufficient to produce the inferred resuits, and accordingly he consulted Mr. J. R. D. Francis of the Thomas Hawksley Hydraulics Laboratory at Imperial College, London. Mr. Francis referred the writer to two very important papers recently presented to the Royal Society[5], "The Action of a Surface Current used as a Breakwater" by Sir Geoffrey Taylor, and "Pneumatic and Similar Breakwaters" by J. T. Evans. Taylor sets out the theory and Evans gives experimental results. These papers form the most comprehensive logical treatment of the subject to date, and should be read by all engineers interested in the subject.

These authors, following J. Thysse of Delft, discard the idea that bubbles reduce waves by means of the turbulence they generate, and trace the effect to the vertical current of water which is induced by them. The vertical current spreads out horizontally at the surface into two thin currents, one opposed to wave action and the other flowing in the same direction as the waves. The opposing current, if sufficiently strong, stops the waves and in other circumstances causes them to become steep enough to break. The use of bubbles is an inefficient method of creating vertical and horizontal currents, and from a power standpoint water jets would be much better, although no doubt there are problems in practical application.

Taylor calculates a surface current velocity of 15 ft./sec. for a stream thickness of 1.6-ft. as being sufficient to stop waves of 100-ft. length. (The power represented by this current is only 9.5 h.p. per foot width, much less than the huge power requirements generally attributed to bubble breakwaters). Where the velocity of the current is insufficient to stop the waves, or to cause breaking the waves will be shortened and made higher, and in this condition may well do more damage to a nearby structure than would the unaltered wave. So, where these conditions are artificially produced, as with a pneumatic breakwater, the siting should be chosen with care, otherwise the result could be more destructive than it would have been if things had been left alone.

A very great quantity of water under considerable pressure would be required to produce the 15 ft./sec. current mentioned above. Twenty-four cusecs would be needed for a width of one foot, and if the frontage were a mile long the requirement would be 140,000 cusecs; this is equivalent to the flood flow of the River Po. In order to stop longer waves a much greater flow would be needed.

It is difficult to see how any appreciable flow could be obtained at high velocity from a drowned river valley filled with drift material or from fissures in the limestone bottom. A general diffusion would be more likely, accompanied perhaps by stronger discharges here and there. These discharges would cause surface phenomena under certain sea conditions on calm days, on account of differences of density and temperature, but they would have little effect during storms.

Sir Geoffrey Taylor's mathematical investigation is based on the assumption that the bubbles are very small and that their sole function is to entrain water for the production of surface currents. This is the point where A. H. Laurie[6], who reviewed the recently published report on German Experiments on Pneumatic Breakwaters, comes in with a fundamentally different conception. He is firmly of the opinion, based on observation of pneumatic breakwaters and of specific occurrences in Nature, that wave reduction can be achieved by a technique other than the orthodox methods hitherto employed for producing surface currents. His basic idea is that the effect of bubbles is neither one of turbulence nor of induced vertical currents, but is due to a boundary effect. The bubbles create a screen effectively producing discontinuity in the wave motion of the fluid. Wave energy is reflected in whole or in part; in either case much wave energy is destroyed in the area seaward of the boundary layer resulting in great confusion of the surface in this zone, while the water is calmer on the landward side. Since only a boundary has to be provided the power requirement is relatively small, and is only a small percentage of that deduced by Schijf, Taylor and Evans, who have said it would have to be very great on the basic of induced water currents. It would be interesting if a pneumatic breakwater embodying the new technique were constructed to Laurie's design and put into use. If it was effective then the model tank findings on this subject, basically agreed by such experienced engineers as those mentioned above, would need to be revised.

J. Larras[4], on the other hand, is not concerned with Geohydrological breaks. He assumes perfect fluids and sinusoidal waves and then finds that clapotis from such waves reflected off a breakwater have maximum heights at certain distances along it. He then assumes that damage is proportional to the height of clapotis. His table of calculated distances of maximum clapotis and of actual damage is convincing except that he assumed that waves of 100 metres, which fit the theory, were present. Before accepting this correlation of theory and damage, it would be necessary to examine the actual wave trace. This is a common occurrence in the engineering of maritime structures; ingenious theories are worked out, and designs are related to wave lengths and heights, but the actual heights and lengths are seldom measured.

It is questionable, in the author's view, whether any one explanation of the disaster is by itself sufficient to account for the damage at Genoa. However, in the absence of the fullest data relating to the occurrence, it has not perhaps been entirely unprofitable to investigate some of the opinions put forward. These reveal how truly complex the problem is.

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Montevideo Port Conditions

The annual report of the British Chamber of Commerce, Montevideo, for 1954-55, states that notwithstanding the efforts and good will displayed by certain departmental executives to bring about an improvement in port working conditions the situation deteriorated during the year. An average of 39 ships a week called at Montevideo and there was periodic congestion due to lack of adequate discharging, loading and storage facilities, as well as to the poor results obtained from labour. The port administration have found it essential to compel ships to work considerable overtime in the discharge of general cargoes in order to free quay berths for incoming ships.

Regulations restricting the weights of each sling of cargo, and the lack of modern handling equipment, have also impeded the quick and efficient turn-round of vessels. Deep-sea tonnage that operated at up-river ports obtained quicker dispatch in loading than in Montevideo. The shore labour and stevedores received the same wages as at Montevideo but did double the work per eight hours shift.

Notwithstanding efforts made by the Shipping Centre at Montevideo the stevedores have sought every opportunity to claim "dirty cargo" rates, even to the extent of causing damage to containers of commodities classed as "dirty" with the result that handling of clean cargo in the same hold has had to be paid for at "dirty cargo" rates.

During the year the stevedore foremen claimed increases in wages and demanded direct dealings with ship agents instead of adhering to the law governing wage awards, but the Government took a firm stand and compelled the foremen to accept the Government wage board award.

Pilfering has not diminished in any appreciable degree. Pilfered goods which are smuggled out of the port zone are sold freely in and around the port area with apparent immunity. Watchmen, who have also to be employed in strict order of rotation from the Government Labour Bureau, are not capable of taking effective preventive action, the report states.

The obsolete regulations governing the carriage, handling and storage of inflammable and dangerous goods have come up for revision and it is hoped that new regulations will be drawn up.

The Hopper Dredge

Its History, Development and Operation

A Review of a Publication by the Office of the Chief of Engineers, U.S. Army.

(Continued from page 191)

MACHINERY AND CONTROL

Five types of power plants are employed on hopper dredges, viz. steam turbo-electric, diesel-electric, direct diesel, combinations of direct diesel and diesel-electric, and steam reciprocating. Steam turbines and diesels have superceded steam reciprocating engines. The need for close control of propeller revolutions throughout the entire range, variable dredge pump drive speed and variable speed for hoisting machinery have led to direct current being used almost exclusively for electric power in the Corps' hopper dredges. Turbo-electric power is favoured for large and medium dredges and diesel-electric for smaller ones.

The factors influencing the selection of the type of propulsion are quoted in full:—

"(a) Manoeuvrability and adequate and efficient power for shallow draft hulls, require a hopper dredge to have twin screws separately powered.

(b) The space available for hoppers and machinery, taking into consideration the draft and trim of the dredge, may dictate the use of a particular type of power plant.

(c) Weight per horsepower becomes especially critical in the design of a small shallow draft dredge.

(d) Pilothouse propulsion control is highly desirable, and the power plant should lend itself to a simple type of control, preferably electric or pneumatic.

(e) A prime mover of suitable characteristics and permitting remote control must be provided for the dredge pump. The desirability of using an electric motor for this purpose is a factor which influences the choice of electric power for propulsion and other services.

(f) Normally a hopper dredge operates 24 hours a day, 5 to 7 days a week. Because of such continuous operation, high operating economy is important.

(g) A hopper dredge operates for long periods at reduced propulsion power. The propelling machinery should therefore be of a type that will perform satisfactorily and with reasonable efficiency at partial loads.

(h) When hopper dredges are designed for high free running speed and as a consequence there is an excess of power available while dredging, it is often possible to divert some of this power to the dredge pumps at that time. This keeps the installed horsepower of the prime movers to a minimum.

(i) A hopper dredge frequently requires full astern power, a fact that precludes the use of a direct connected geared turbine drive which has limited astern power.

(j) Propeller speed should be capable of variation in both directions and in small increments from zero to maximum. Any type of prime mover which does not have this feature should not be favourably considered."

The emphasis on flexibility, manoeuvrability and ready control is manifest.

The preference for twin propellers has already been mentioned. This feature is further developed in the following passage, which is again quoted in full.

"Because of the full-bodied hull form and the relatively slow speed typical of hopper dredges, it is desirable from the standpoint of efficiency to have propellers of as large a diameter as physical conditions will permit. Propellers of large diameter, with correspondingly low revolutions per minute, perform most satisfactorily at the higher values of real slip at which the propellers for this type of vessel are called upon to operate, both in the free-running fully loaded condition and in the dredging condition, with the drags on the channel bottom. In the latter condition the propellers must develop enough thrust to propel the dredge against currents and to overcome the resistance encountered by the drags moving over the bottom."

"In order to provide adequate clearance between the blade tips and the hull, at the same time keeping the propeller circle within the prism of the hull, it is often necessary to choose a propeller whose diameter is somewhat less than that required for maximum efficiency. This is particularly true of dredges, where the stern lines are frequently quite full, and where the draft is restricted by the requirement for operation in shallow water. Since dredges sometimes operate in water so shallow that the bottom of the hull is practically in contact with the channel bottom, it is imperative that ample clearance be provided to avoid damage to the propeller blades. The above factors, together with the requirement for adequate propeller immersion in light and loaded conditions, will usually dictate the maximum permissible diameter of the propeller."

"Four-bladed propellers have become standard for dredging service. A large projected blade area can be obtained by using this type without resorting to extreme blade shapes due to cavitation limits. A three-bladed propeller having similar characteristics would have to be greater in diameter than would be permissible on a particular dredge."

"Propeller blades of outline similar to those on modern merchant ships have been used on dredges recently built but the blade area is made somewhat greater in order to avoid cavitation under dredging conditions during which the propellers are heavily loaded. Projected area ratios cover a range between 0.40 and 0.47. Recent practice has been to provide some skew-back and rake to the blades."

"Blades should be given ample thickness near the edges so that they will not be too readily damaged by contact with the channel bottom or by striking floating objects. Although the increased thickness at the blade edges will cause some loss in efficiency, the additional metal is desirable from the standpoint of maintenance. In order to provide the best water flow in the vicinity of the heavy sections at the blade root, blade sections near the hub should be of airfoil shape, with the driving face given some 'washback' which decreases and eventually disappears in the vicinity of one-half radius. The shape of the back of the blade should gradually assume a circular section near the tip of the blade."

"In the past, many dredge propellers were of the built-up type, with the blades cast separately and bolted to the hub. This type of propeller has the advantages of permitting replacement of individual blades, and adjustment of the pitch. The disadvantages of the built-up type of propeller are higher first cost, greater weight and lower efficiency, the latter due to the larger hub necessary to accommodate the blade fastening. Built-up propellers are no longer practical for hopper dredges."

"In dredging service, lengths of wire rope are frequently picked up by the drags. To prevent them from becoming lodged between the propeller hub and the strut or stern bearing which might result in damage to the hubs and shafts or in a locked shaft, it has been found advisable to close off this space by means of a guard, usually made of half-inch steel plate, rolled into cylindrical shape and installed in halves."

Turbo-Electro Dredges.

To illustrate the machinery of a modern turbo-electric dredge, the "Comber" has been selected. She is a 3,000 cubic yard dredge, built in 1947.

The entire main power plant is situated after of the hoppers in three compartments and is distributed vertically for the most part on three levels; the hold, the lower deck, and the main deck. The port and starboard machinery consisting of turbines, generators and propulsion motors are independent of each other. Except for the dredge pump generators in the motor room, and the drag-arm hoists on the upper deck, all machinery closely related to dredging is installed in the dredge pumproom towards the forward end of the hull. The dredge pumps are placed as low as possible to reduce the suction lift.

The machinery in the "Comber" is described and illustrated in some detail. In this review it will only be possible to catalogue some of the main items and this will serve to indicate their type and capacity.

Hopper Dredge—*continued*

Boilers. Two, single-pass, inclined sinuous header, cross drum, water-tube marine boilers, fitted with water walls, superheaters, desuperheaters (for certain auxiliaries where superheated steam is not desirable), air pre-heaters, oil burners, soot blowers, feed water regulators and automatic combustion controls. The last named equipment together with wide range burners and automatic water feed regulators are necessary because of the varying steam demands.

Turbine. Two main turbines, of the combination impulse and reaction type, rated at 3,000 kilowatts at 5,400 r.p.m. when supplied with steam at 440 pounds per square inch and 740° F., exhausting to a vacuum of 28.5 inches of mercury. Each turbine drives the generator at 514 r.p.m. through single-reduction, double-helical gear. The turbines operate at constant speed.

Principle Generators. Fig. 6 illustrates one of the two main sets in the "Comber." First on the line is the propulsion unit; a marine type, shuntwound, direct-current generator, rated 2,450 k.w., 600/720 volts. The dual voltage rating is needed to meet the requirements that constant horsepower is to be maintained at all times when the control is on the full speed point.

The dredge pump generator is next. Similar to the propulsion generator, it is rated at 925 k.w., 600 volts.

Thirdly, the auxiliary generator is rated at 300 k.w., 120/240 volts.

Propulsion Motors. 3,000 h.p., 600/720 volts, 100/120 r.p.m.

Dredge Pump Motors. Stabilised-shunt-wound, direct current, marine type, rated 1,150 h.p., 600 volts, 180/205 r.p.m.

The drag-arm hoists are powered by waterproof, reversible shunt-wound, direct current motors, having a 2 hour rating of 125 h.p., 230 volts, 690 r.p.m. Power for each motor is from a motor-generator set comprising a 150 h.p., 240 volt motor, a 103 k.w., 240 volt generator and a 1 k.w., 90 volt excitor. The jetting and unwatering pump is driven by a shunt-wound motor rated at 100 h.p., 230 volts, 510/750 r.p.m., and the hydraulic hopper door system pump is gear-type, driven by a motor rated at 75 h.p., 230 volts, 575 r.p.m.

Practically all auxiliary machinery is electrically operated or driven. The auxiliary generators are driven by the main turbines when the dredge is operating and by a stand-by turbine generator set when she is idle.

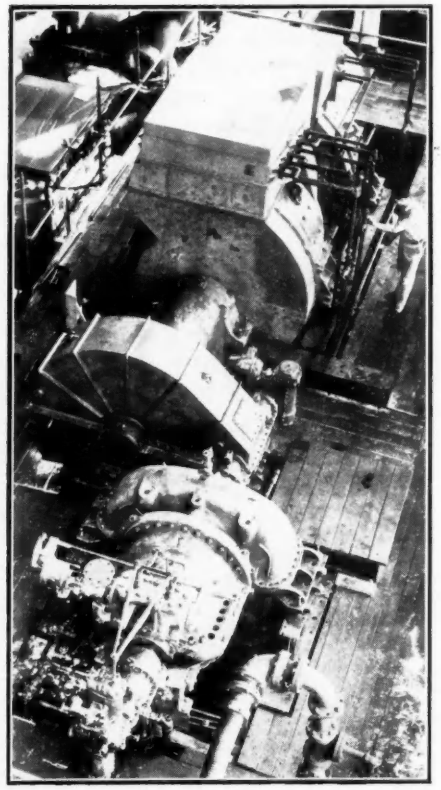


Fig. 6. Dredge "Comber" Generating Set.

An emergency 60 k.w. diesel electric set is provided, and an A.C. set is installed to permit the use of current from the shore.

Diesel-Electric Dredges.

In the 700 cubic yard dredge "Lyman" which is typical of the diesel-electric class, the power plant is aft in two compartments. Each compartment contains one main engine driving two generators; firstly, the propulsion generator, and secondly, a generator serving both the dredge pump motor and auxiliary motors.

The main diesels are 12 cylinder V-type, two cycle engines, 8¾-in. bore, 10½-in. stroke, 950 b.h.p. at 750 r.p.m. when operating with a brake mean effective pressure of 66.2 lbs. per sq. inch.

The propulsion generators are rated 565 k.w. at 600 volts and 750 r.p.m. and the auxiliary generators are rated 310 k.w. at 120/240 volts and 750 r.p.m. Both auxiliary generators combine to feed one dredge pump motor, the pump serving two drag-arms.

In shallow draft dredges like the "Lyman," there is insufficient depth to accommodate large diameter, slow speed motors required for direct drive; therefore high speed motors driving the propellers through reduction gear are used. Weight and space being at a premium, light high-speed engines are most suitable as generator prime movers. Conservative rating is necessary to ensure reliability and long life in conditions of continuous service. The brake-mean-effective-pressure is a good criterion, and the figures cited above represent what has been found to be good practice.

Table 1 indicates the reduction in weight per horsepower obtained since 1924.

The propulsion motors are shunt wound, and rated 700 h.p. at 600 volts and 1128/1200 r.p.m. Motor and propeller shafts are connected through flexible self-aligning couplings to the reduction gear which is capable of delivering 700 h.p. to the shaft at 188/200 r.p.m.

The dredge pump motor has a continuous rating of 410 h.p. at 230 volts and 190/240 r.p.m. Fifteen points of field control are provided within the 190 to 240 r.p.m. range.

Much of the dredging machinery on the "Lyman" resembles that on the "Comber" but is of lower capacity. Table 2 gives a comparison.

Combination Diesel and Electric Dredges and Steam Driven Dredges.

It is not proposed to precis the chapter dealing with these types of dredges. Three of the first type have been constructed by the Corps of Engineers, none of which are typical. All hopper dredges built prior to 1924 employed reciprocating steam engines for propulsion and for driving dredge pumps. Either compound or triple expansion vertical engines were used, directly connected to propellers and dredge pumps, and all other machinery was steam operated.

DREDGE PUMPS

The chapter on dredge pumps commences with a section tracing the development of this specialised type of pump, proceeds to deal with tests and ends with a section on

TABLE 1

Item	Hp or kw capacity	
	COMBER	LYMAN
Draghoist M-G set motor	105 hp	75 hp
Draghoist M-G set generator	103 kw	35 kw
Draghoist M-G set exciter	1 kw	¾ kw
Draghoist winch motor	125 hp	40 hp
Hydraulic pump motor	75 hp	20 hp

TABLE 2

Dredge	Year	Cycle	Rpm	Bhp	Weight	Lb/Bhp
KINGMAN	1924	4	150	1,000	350,000	350
TAYLOR	1926	4	250	600	89,000	148
PACIFIC	1937	4	450	400	30,000	75
HARDING	1939	4	250	1,000	111,924	112
HAINS	1942	2	750	950	23,800	25
LYMAN	1945	2	750	950	23,800	25
MACKENZIE	1949	2	675	1,460	28,400	19.5

Hopper Dredge—continued

design. The last two sections are particularly informative and interesting, and with the kind permission of the Editors, they are quoted in full.

Dredge Pump Tests

"Reliable data based on simulated or actual operating tests on dredge pumps are very scarce. It is difficult to simulate actual working conditions in a laboratory and therefore such experiments are usually conducted with water as the medium. It is difficult to conduct experiments on a dredge while pumping materials because it is practically impossible to maintain uniform conditions for any length of time. Nevertheless, some tests have been conducted and have proven of great benefit to the Corps of Engineers and others interested in the manufacture and application of dredge pumps. The more notable cases are briefly described here."

"From 1936 to 1940, a number of hydraulic experiments specifically concerned with dredge pumps and with the transportation of sand in pipelines were conducted. The Bonneville Hydraulic Laboratory conducted two series of experiments between 1936 and 1938, the first of which consisted of studies of a model of an 18-in. dredge pump for the "Pacific" which was then being designed. The objectives of these studies were to determine the direction of flow at various locations within the pump, to study the distribution of pressures, velocities and energy gradients, to determine the thrust and effect of service water, to determine the possibility of priming a dredge pump as arranged on the "Pacific" without using a flap check valve in the discharge line, to study the effects of using two suction lines to a single dredge pump, and to examine the behaviour of objects drawn into the pump. Similar tests were conducted in 1938 with a model of a 28-in. pump to be used on the Fort Peck Dam project. These latter tests also included a study of several impellers having different vane angles and contours, the effects of volute velocities on wear in the pump, the influence of relief holes in the back shroud of the impellers, and the effect of using a tongue extension at the throat."

"The University of California published a paper in 1939 by O'Brien and Folsom entitled 'The Transportation of Sand in Pipelines,' valuable for its study of settling velocities of particles in water, minimum velocity required for transporting solids and the effects of sand-water mixtures on the total head developed by a dredge pump. The transactions of the American Society of Mechanical Engineers for 1929 included a paper by Polhemus and Healy, reporting the results of tests conducted to determine the effect of clearances on thrust in a dredge pump. In these tests, measurements were made on an actual pump, instead of on a model."

"Tests have been conducted from time to time on Corps of Engineers hopper and pipeline dredges to check the efficiency of various designs when pumping water. Some significant curves resulting from the tests of one of the 'Langfitt's' dredge pumps are reproduced in Figs. 7, 8 and 9."

"By way of contrast, curves comparable to those of Fig. 9 are presented in Fig. 10 for the 'Michie' pump designed in 1915."

DESIGN

"Much of the design of dredge pumps is based on empirical data, on tests, on experience, and on some as yet unpublished information. Certain details, therefore, vary considerably with different designers and manufacturers. The chapters which follow present some current design parctices of the Corps of Engineers and such theory and formulas are as essential to a clear understanding of the text. The reader is referred to the bibliography for references where elaborations of the theory can be found."

1. Design Criteria.

"In order to design a dredge pump, certain basic data are needed, some of which is determined directly from the physical dimensions of the dredge, some from theoretical and practical considerations and some from actual experience."

"Static heads are fixed by the depth to be dredged, the elevation of the centre line of the pump with respect to the water surface, and the height of the discharge system above the pump."

"The quantity of the mixture which is to be handled depends upon the dimensions of the hoppers and the amount of power available for driving the pump. This quantity can be varied through a rather wide range to suit other limitations such as optimum diameter of suction and discharge pipes."

"Dredge pumps for sea-going hopper dredges are usually designed from the head standpoint for handling sand which has a weight of 110 to 125 pounds per cubic foot. The practical limits for pumping such material are 15 to 20 per cent. by volume at a suction velocity between 15 to 20 fps. Pumps designed on this basis are capable of handling efficiently such other material as may be encountered."

"The maximum theoretical suction head which can be developed by a pump is that corresponding to a perfect vacuum, or 33.99-ft. of fresh water at sea level and standard barometric pressure. A dredge pump never approaches this value and for design purposes, the total computed suction head should not exceed about 30-ft. As a matter of practice, it is expedient to limit the total suction head when pumping water only, to a value not exceeding 18-in. of mercury, or approximately 20-ft. The margin between this figure and the maximum which the pump can develop is then available for lifting and transporting dredged solids."

2. Determination of Head.

"Before undertaking the design of a dredge pump, the total external head against which the pump must work is determined by an analysis of each element of the system. In order to reduce all heads to a common basis, they are here expressed in terms of feet of water having a specific gravity of 1 or a weight of 62.4 pounds per cubic foot, hereafter referred to as "Fresh Water." The components of head and the means of computing them are as follows:

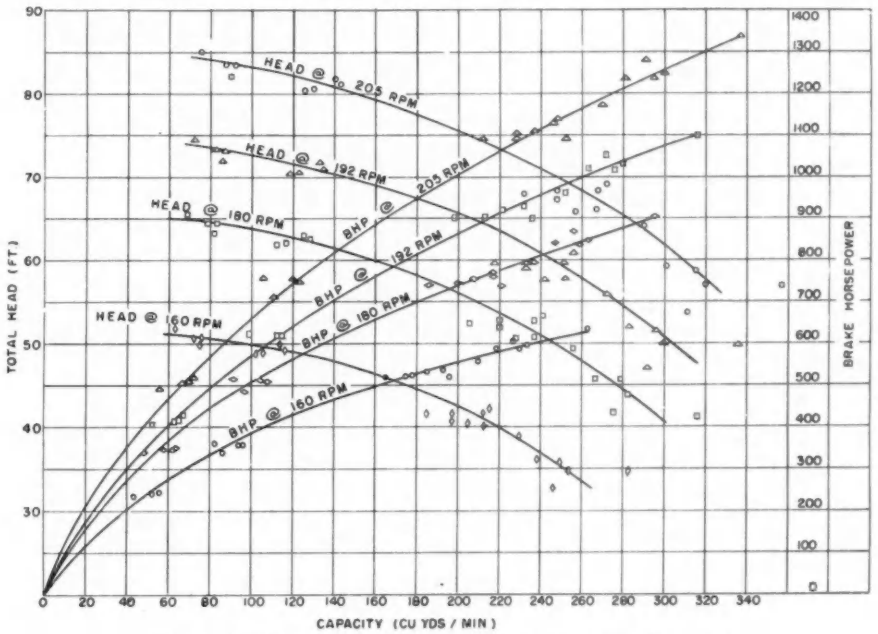


Fig. 7. Dredge "Langfitt" Dredging Pump Head-capacity curves.

(a) Static Suction Head. If the pump is handling fresh water only, the static suction head is the vertical distance in feet between the surface of the water being pumped and the centreline of the pump suction. This may be additive or subtractive, depending upon whether the centreline is above or below the surface of the water. However, when sea water is involved or if it is desired to obtain the static suction head when pumping a mixture of solids and water, corrections must be made for the density of these mediums. The following formula may be used in computing the static suction head.

Hopper Dredge—continued

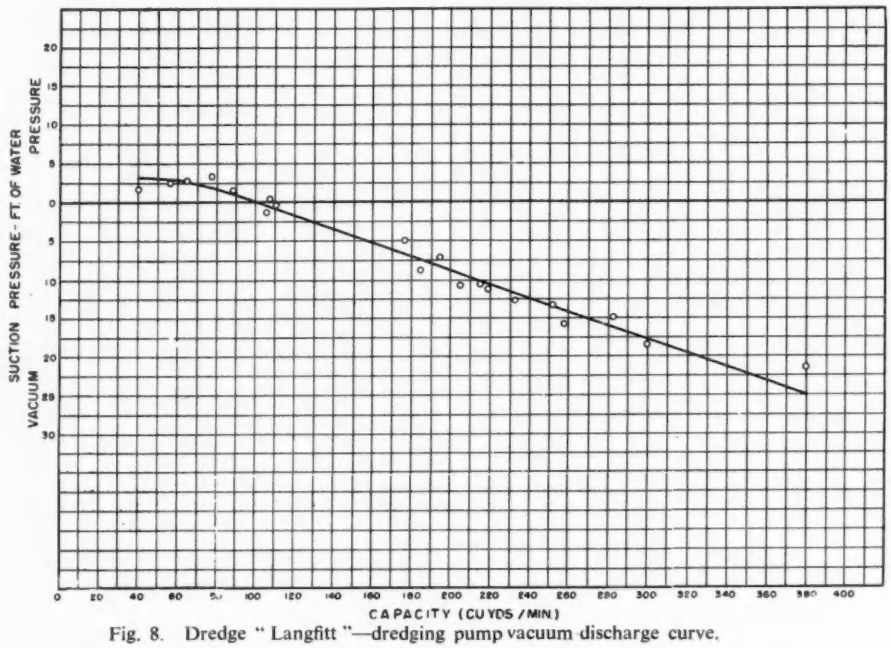


Fig. 8. Dredge " Langfitt "—dredging pump vacuum discharge curve.

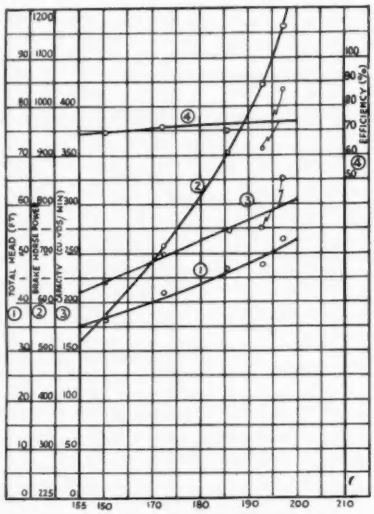


Fig. 9. Dredge " Langfitt "—dredging pump speed-discharge curves.

$$H_s = S_1C - S_2B$$

where:

H_s = Suction static head in feet of fresh water.

C = Distance of water surface above the channel bottom, in feet (dredging depth).

B = Distance of centreline of the pump above the channel bottom.

S_1 = Specific gravity of the water in which the dredge is operating (1.025 for sea water).

S_2 1 = Density of the mixture being pumped.

If the application of the formula results in a positive value, this should be subtracted in computing the total head; if it is negative, it must be added.

(b) Suction Velocity Head. This is the head required to accelerate the mixture to the velocity attained in the drag pipe and is determined from the formula

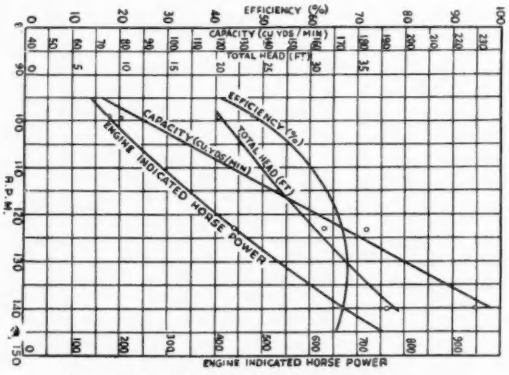


Fig. 10. Dredge " Michie "—dredging pump speed-capacity and related curves.

$$h_v = S\frac{V^2}{2g}$$

where:

h_v = Head in feet of fresh water.

S = Density of mixture.

V = Velocity in suction line in fps.

g = Acceleration due to gravity (32.2fps./ps).

(c) Suction Friction Head. This includes all friction losses in the suction system and entrance losses at the drag. The friction head in the pipe and fittings can be computed from the formula

$$h_f = 0.02\left(\frac{P-10}{1+\frac{100}{}}\right)\frac{L}{d}\times\frac{V^2}{2g}$$

where:

h_f = Friction head in feet of fresh water per foot of pipe.

L = Length of pipe in feet (including equivalent length of fittings).

d = Diameter of pipe in feet.

V = Velocity through pipe in fps.

g = Acceleration due to gravity (32.2 fps./ps.).

P = Percentage of sand in suspension by volume.

The constant 0.02 is the value established for a mixture containing 10 per cent. of sand flowing through pipes at velocities within the range under consideration. The quantity in parentheses is a correcting factor which adapts the formula for percentages lower or higher than 10 per cent.

The equivalent length of straight pipe can be found for elbows and all standard fittings from standard tables. The friction loss through ball-joints and the entrance loss at the drag heads are computed from the formula:

$$h_f = C\frac{V^2}{2g}$$

The value of C has not been determined by accurate experiments but figures of 0.4 to 0.5 for drags and 0.75 to 0.10 for ball-joints are approximately correct. The magnitude of the friction loss through these parts is small and the errors occasioned by using approximate values of C are negligible.

(d) Static Discharge Head. This is the vertical distance between the centre of axis of the pump and the highest point in the discharge system measured in feet. The static head thus determined must be multiplied by the density of the mixture to obtain the true value in feet of fresh water.

(e) Discharge Velocity Head Loss. This is the change in velocity head which occurs in the discharge system if the suction and discharge pipes are not of the same diameter. In modern pumps the suction diameter is usually larger than that of the discharge, with the result that the velocity head is slightly increased at the discharge. The change is computed by the formula:

$$h_v = S^v\frac{d^2 - V_s^2}{2g} \qquad (4)$$

where:

h_{vd} = Discharge velocity in feet of fresh water.

V_s = Velocity in suction pipe, feet per second.

V_d = Velocity in discharge pipe, feet per second.

g = 32.2-ft. per second per second.

S = Density of mixture being pumped.

(f) Discharge Friction Head. This is computed in the same manner and using the same formula as for the suction friction head."

An example of the determination of head is given in the continuation of this review which will be published in the December issue of this Journal.

Trade at the Port of Beira.

The Beira Port Authorities report that during September the cargo handled in the port reached a record tonnage. Imports totalled 153,380 short tons, and exports 171,109 tons. An exceptionally large amount of chrome was shipped during the month. From January to August a total of 2,016,001 short tons was handled, comprising 1,067,969 tons exports and 948,032 tons imports. This compares with 2,906,918 tons in the corresponding period of last year, when exports amounted to 1,459,074 tons, and imports 1,447,844 tons.

Book Reviews

Handbook on Peiner Steel Piles (Peiner Kastenspundward) by Dr. Otto Baer published by Huttenwerke Ilsede-Peine A.G. Peine. 8vo.

This second and entirely new edition of the Peiner Handbook on steel pile walls is a well printed and illustrated volume of text book size and is both instructive and informative. It contains many of those details of construction and design which are useful alike to student and professional engineers. There are 10 chapters, 320 pages and about 200 illustrations of line drawings, diagrams and photographs of examples in construction and completion.

Dr. Baer devotes the first three chapters to the history of the development and improvement of the original H section (1911) to the present day section, stress tables and properties, various sectional forms for special jobs, and combinations with other sheet pile sections. Chapters 4 to 6 deal with the uses of steel piles and sheeting for retaining walls, quay walls, sluice walls etc. Details in working drawings of tie-bars and anchorages, accompanied with stress tables, connections for bollards, fairleads and copings are given. A chapter on the extension of application to increase the sturdiness of other makes of sheet piling in use as bearing piles is treated methodically and without bias, economy and efficiency in the use of steel being the criteria. There follows a chapter on ground tests of the Peiner pile and a further short chapter on the increase of impermeability of walls by the use of a special machine for the improved closure of the clutches.

Chapters 8 to 10 occupy two-thirds of the volume and are devoted to examples of construction (quay walls, dolphins, abutments, breakwaters, etc.), practical details of driving, driving machines, leads, slinging and inclined driving. The final chapter gives working examples of particular problems in computing materials required, stresses etc. supported by graphical analyses based on the latest data of modern soil mechanics. Fig. 1 is an illustration of the upstream head of the recently constructed mole enclosing the Hamburg-Altona Fish Dock from the River Elbe. The inner side to the right of the photograph is the fitting-out quay for sea-going trawlers. The mole is enclosed by double units of Peiner piles separated by shorter double unit Krupp steel sheeting as shown on inset, a dummy Krupp unit being used to drive the Peiner units spaced apart.

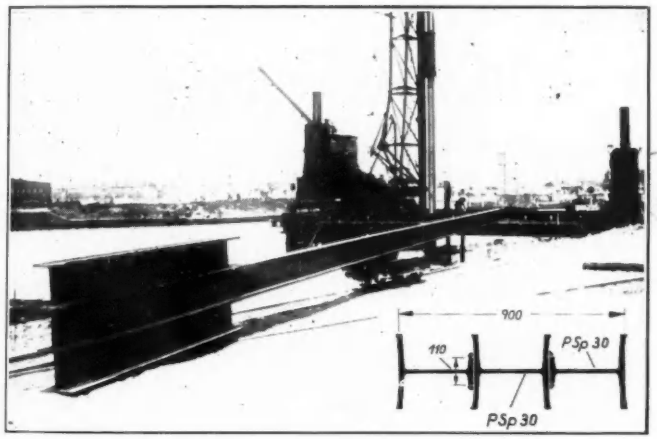


Fig. 1.

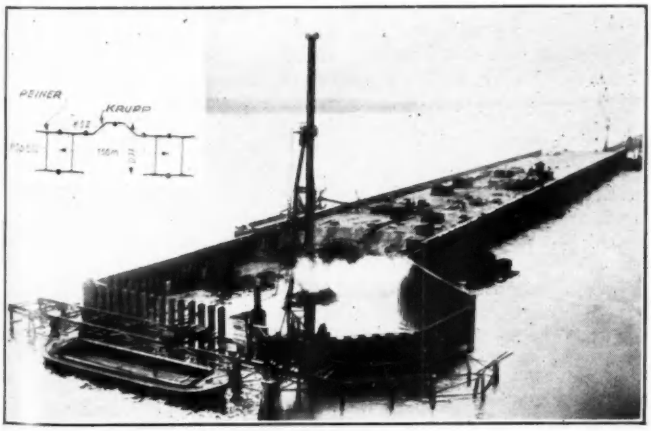


Fig. 2.

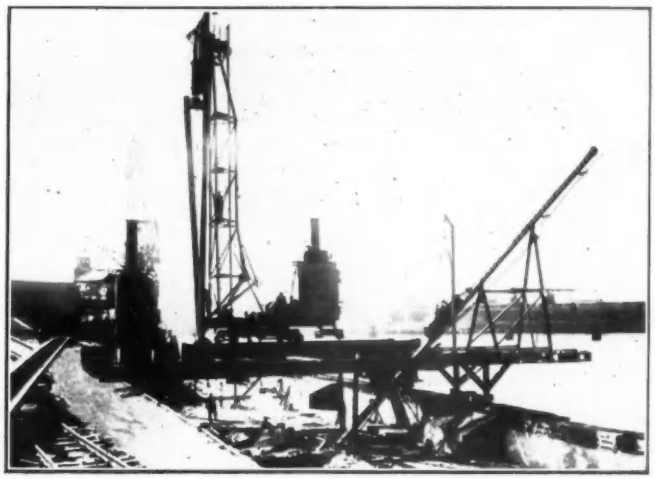


Fig. 3.

A robust form of diagonal bracing pile was devised for several of the quay walls of the Hamburg docks. This was achieved by welding short lengths of Peiner section to the main arm, as shown in Fig. 2. They were also used in the construction of the Versmann quay and the Schamer quay at inclinations of 1 : 1. The pile driving rig is that shown in Fig. 3.

Although written in German this is a book which would be useful to any engineer engaged on steel piling construction works.

"An Introduction to Port Working" by A. H. J. Bown, O.B.E., F.C.I.S., M.Inst.T.

Early in 1954 the National Dock Labour Board decided to publish and make available to dock workers standard handbooks on the port transport industry, at a price which would be within the dock workers' ability to pay. The first publication under the new scheme was a special cheap edition of "Port Operation and Administration" (by Bown & Dove), which was sold to dock workers at 5s. per copy.

The second book "An Introduction to Port Working" (just published) is being sold to those employed in the dock industry at 1s. per copy and is available to the public at 2s. 6d. a copy. The Board states that this book is designed as an elementary handbook suitable for use in the training classes for dock workers which it has organised throughout the country, adding that the various subsections follow very closely the syllabus for those classes.

The author has presented his subject in three chapters, viz. Port Working, Port Traffic, and Port Organisation and Finance, and although the information given is in summarised form, the subject is nevertheless dealt with comprehensively. Chapter one (Port Working), for example, covers loading, discharging and berthing vessels; warehousing; transhipment and entrepôt trade; effect on working of the nature of the traffic handled; port layout; rail, road and water connections; equipment and appliances; lighterage; labour and methods of payment; passenger traffic; the effect on working of port organisation; and the relation of port working to port finance. The other two chapters are equally comprehensive and although lecturers using this book would naturally have to amplify its contents, there is probably little of importance they would have to add.

Ports differ so widely in so many aspects that any book written upon port working will receive criticism. The work under review, however, will not be faulted on many major points—in fact, the

Book Reviews—continued

only important doubt which springs to mind is whether here and there it is too advanced for the purpose in view. Occasionally, the text includes statements with which all British port officials would not agree. For example, the statement that " an exporter sending goods to the docks by his own or hired vehicles will give advanced notice to the dock staff and a programme of deliveries will be arranged in outline " certainly does not describe current practice at all British ports, in many of which, under present very busy conditions, such an ideal state of affairs would be impracticable. Another statement, in a completely different category, will also be disputed in certain quarters. " The port engineer will consult continuously with the general manager but he reports directly to the works committee and the board on his own professional and technical matters." However, these are minor matters and many parts of the book—the section on Industrial Relations, for example—will be of interest and use to port officials as well as to dock workers.

For its proclaimed purpose, "An Introduction to Port Working " is an excellent publication.

Bow-suction Dredger and Cargo-vessel-dredger

In recent years, a new type of dredger has been invented and although no vessels have been built according to the new design, the idea appears to be of sufficient interest to warrant giving some detailed information.

The new type of dredger was developed by Mr. F. Fendel, Director of a navigation company in Germany and Mr. L. Kort, the inventor of the Kort nozzle, after they had seen the effect of propellers running in bow nozzles. During a trial run of a twin-screw cargo vessel with bow nozzles, the steering gear broke down and the vessel ran into the bank of the canal before engines could be stopped. It was noted that a large gap was formed in the bank, in a remarkably short time. The inventors originally proposed building a self-propelled cargo vessel with bow nozzles and with a specially-shaped bow for improved intake of material from the bottom of the channel. It was felt that such a vessel could pass shallow sections even if the depths were less than its draught, which would obviate the need for discharging part of the cargo. Further development of this idea led to the design of the bow-suction dredger. During the second world war, a patent was applied for and at the same time the Hamburg test tank was requested to carry out a number of model experiments. After completion of the experiments, construction was started on a bow-suction dredger for the Weichsel river but this vessel was not completed because of the war.

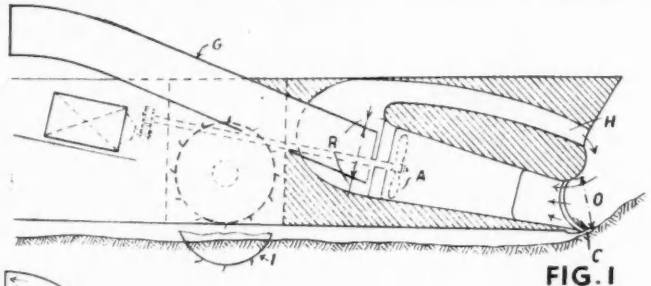


FIG. 1

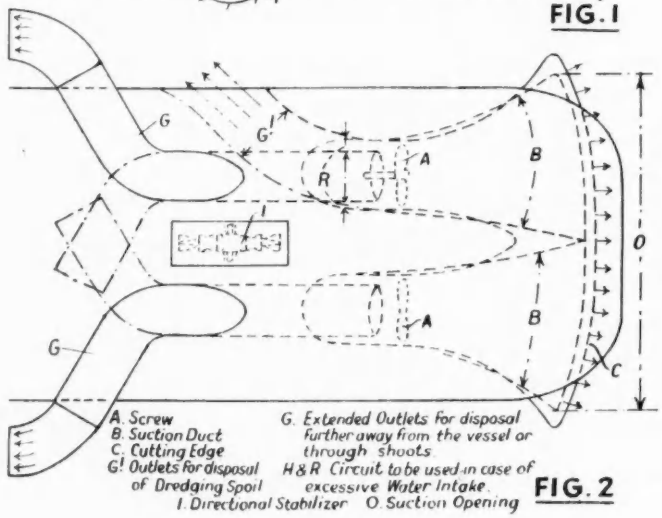


FIG. 2

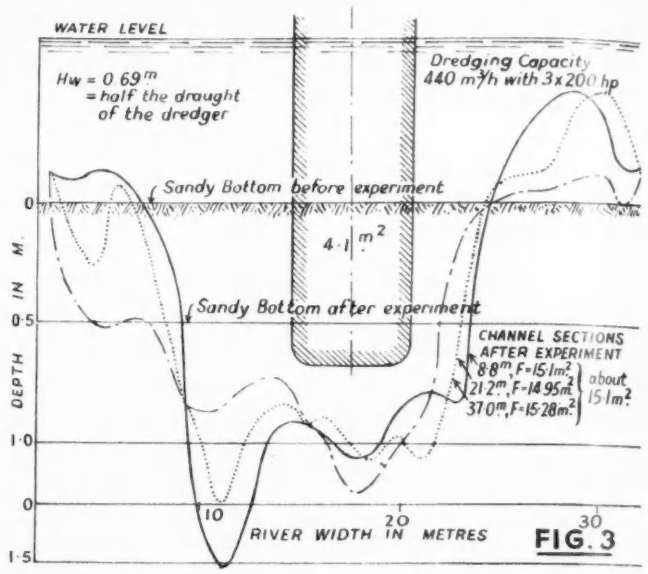


FIG. 3

Figures 1 and 2 show the principle of the dredging head of the vessel. The propellers (a) not only move the dredging spoil but, when the vessel is moving, they also serve to propel the craft. The cutting edge (c) which is fitted at the lowest point of the vessel helps to break through gravel and sand bars and facilitates suction. The suction opening (o) extends over a little more than the full breadth of the vessel. A screen in the suction opening prevents intake of large stones. Any excess of intake water can be returned through a by-pass (past r and h) and will help to loosen the soil in front of the dredger. The dredging spoil can be discharged direct abreast (g^1) or it can be brought through a discharge pipe (g^2) into shoots. As a third alternative it is possible to discharge dredging spoil direct abreast (g) but at a greater distance than in the case of g^1. A special stabiliser has been fitted which consists of a wheel that can be lowered through the bottom of the vessel. This wheel is power-driven and can be raised or lowered as necessary. It serves to keep the vessel on its course when the dredging profile is not symmetrical and it also assists in propelling the craft forward when dredging.

The bow suction cargo vessel will be able to move through shallow parts on which the water depth is only half the draught of the vessel (Fig. 3). This prediction is made on the basis of the tank tests referred to above. The model was fitted with a power equivalent to 3 x 200 h.p. (2 bow propellers and 1 stern propeller) and the effective dredging capacity was the equivalent of 440 m^3/h. During another test with the same model, it was found that, when the depth was two-thirds of the draught, the vessel took about 25 minutes to pass through a stretch equivalent to 100 m. in length. During this test the dredging capacity was measured at the equivalent at 1,540 m^3/h.

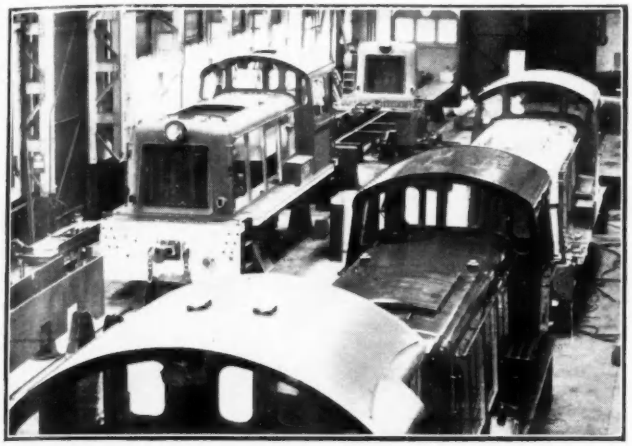
Further tests have shown that it is also possible to use the bow-suction dredger in sand bars which reach to above the water level.

It is said that the advantage of the bow-suction dredger lies not only in its superior dredging capacity but also in the fact that it is entirely independent of tugs for its movements. The dredger can reach any dredging site on its own: its speed is almost as high as that of a cargo vessel of the same power. If necessary, the dredger can even be used as a tug.

Manufacturers' Announcements

Diesel Shunting Locomotives for New Zealand

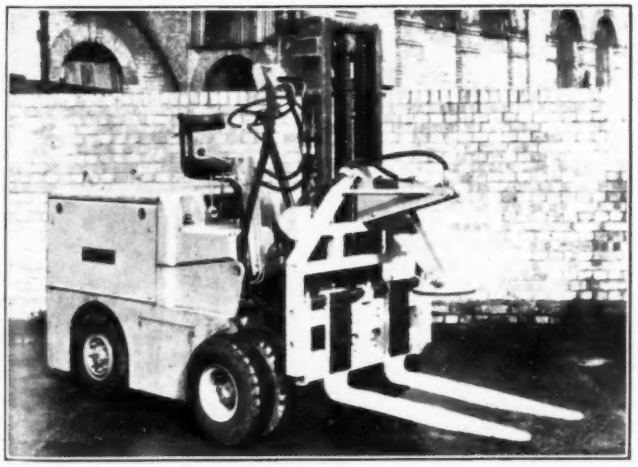
The first of seventeen diesel shunting locomotives of a new design for the New Zealand Government is now being completed at the Castle Works of W. G. Bagnall Ltd., Stafford, England. These locomotives will be used for shunting operations at port installation and at main line stations in the North Island.



Ten of the engines are 240 BHP, with a weight in working order of 30 tons. They are constructed for the New Zealand gauge of 3-ft. 6-in., and the wheel arrangement is 0-6-0. Five gears are provided; the maximum tractive effort in first gear is 16,225 lbs., with a speed of 4.32 m.p.h., while the tractive effort in top gear is 2.132 lbs. at a speed of 32.9 m.p.h. Some of these engines in various stages of completion are shown in the accompanying illustration. Seven engines of 150 BHP are also on order for shunting duties in both North and South Islands.

A New "Stacatruc" Ancillary

A hydraulically-operated load clamping device has been specially designed by I.T.D. Ltd., Ladbroke Grove, London, for use with Stacatruc fork lift trucks and has been developed to provide a positive means of "locking" loads to the forks.



It consists of a rigid support structure (designed to take the place of the conventional backguard and therefore capable of easy fitting) upon which is mounted a cantilever bracket in which a simple system of lever and hydraulic ram is enclosed. The outer end of the lever is provided with a suitable clamping plate pivotally mounted to present the maximum area to the load surface. Operated hydraulically by a two-way valve, pressure can be applied to the double acting ram to produce upward or downward travel of the clamping plate.

Mobile Cranes for Egypt

Chamberlain Industries Ltd., of Staffa Road, Leyton, London, have recently supplied twelve of their standard "Staffa 3" petrol driven mobile cranes to Egypt.

These cranes were purchased for the Egyptian Air Force for airfield duties and an interesting feature of the transaction was that delivery of all twelve cranes was effected within eight weeks of receipt of order.

An outstanding feature is the provision of a robust hydraulic

ram for raising and lowering the jib. Motion is controlled by a conveniently placed lever operating a valve which is completely enclosed within a generous oil reservoir. This finger tip control mechanism gives easier and safer control of derricking operations. An engine driven hydraulic pump supplies the power and the ram unit is safeguarded from failure, burst pipes or obstruction, by means of a specially developed non-return valve.

The crane is constructed on the unit principle, so that if any major part requires replacement, a complete sub-assembly can be supplied for mounting into the main chassis, jig drilled locating holes being used throughout to ensure interchangeability. Replacement units can thus be sent to all parts of the world, since although the internal construction may vary, due to the logical course of future development, the locating holes are always the same size and in the same position.

Another noteworthy feature is that the designers have tried to maintain a very low centre of gravity in order, to further the crane's complete stability and to ensure that it is very efficiently employed on the multiplicity of uses for which it has been designed.

New Corrosion-Resistant Compound

An important new development in the field of corrosion-resisting compounds is the production of a fibre-reinforced plastic material which can be applied by brush on metal surfaces as an effective and economical protection against the corrosive effects of aggressive atmospheres, sea water, hydro-carbon products and a wide range of chemical agents, both in gaseous and liquid form.

The material, known as "V.G. Compound," will be of special interest to all those concerned with the maintenance of structural steelwork, oil refineries, chemical processing plants, etc. It consists of a mixture of a synthetic resin or latex with high-alumina cement, the whole being reinforced with a tough woven fabric by a patented process.

It is applied in two layers, interspersed with the woven fabric, to a total thickness of about 3/32-in. It is cold setting, and the weight of the complete coating is approximately 9 lbs. per sq. yard. Very little preparatory treatment is required; it is sufficient to remove loose scale and rust by wire brush, and the presence of moisture does not impair the effectiveness of the application.

The compound is impermeable and yet flexible, shows no softening at elevated temperatures and has a particularly good impact strength, comparing favourably in this respect with standard concrete. The adhesion strength is also very satisfactory.

The Compound has been produced by V.G. (London) Ltd., of Oxford Street.

Manufacturers' Announcements—continued

Wood Protection against "Soft Rot"

Until quite recently the occasional failure of timber which had been impregnated with creosote or with one of the water-borne preservatives was usually ascribed to poor treatment, to excessive leaching or to gross variations in the timber. It was not suspected that breakdowns were caused by any organism other than those already known, the principal fungal agencies being associated with brown rots and white rots.

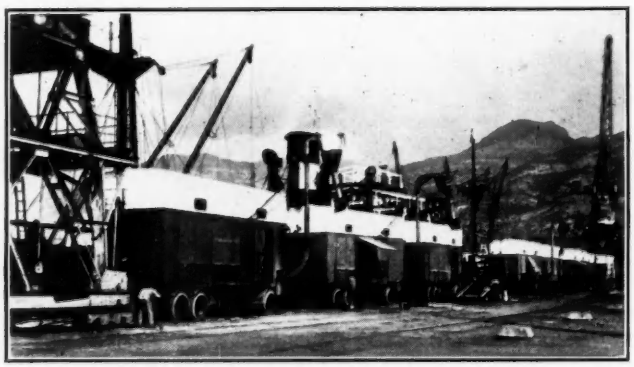
However the incidence of breakdown in the numerous cooling towers erected by the Central Electricity Authority, followed by the collapse of treated transmission poles in Rhodesia led to an intensive investigation which finally resulted in the identification of soft rot fungus hitherto unsuspected as a cause of damage. This fungus was well hidden, in that it operated by travelling longitudinally and secretly within the cell walls of the wood. An intensive investigation, in which the Hickson's Timber Impregnation Company and the Forest Products Research Laboratory have collaborated, has resulted in the formulation of a new "Tanalith" preservative, which in addition to providing the same protection as has been afforded by Tanalith U, also preserves timber against the mould causing soft rot. The new product, known as "Tanalith C," is particularly recommended for preserving timber in ground contact, and for timbers in situations of high humidity, and heavy leaching. The compound is non-corrosive, and has no effect on bolts, screws, nails, etc.; the wood can also be painted and plastered in the same way as untreated timber.

Tanalith C. is recommended inter alia for cooling tower packings, transmission poles, railway sleepers, fresh water piling, boat and ship timbers and sea defence works. The makers are Hickson's Timber Impregnation Co. (G.B.) Ltd., 36, Victoria Street, London.

Unloading Grain at Turkish Ports

A fleet of 48 road trailers fitted with grain handling, cleaning and weighing machinery which was supplied by Simon Handling Engineers Ltd., Cheadle Heath, Stockport, England, to the Turkish Government two years ago were designed to load grain out of ships.

Although Turkey is not usually a grain importing nation, she was recently faced with the task of unloading American grain ships and it seemed that existing handling facilities could not deal with the incoming tonnage. It was suggested, however, that although the Simon trailers were designed to load they would carry out the opposite duty of unloading equally well.



Simon Trailers at Iskenderun.

At Istanbul the ships could not come alongside the shore. The trailers were taken to ships on pontoons and then loaded on board. The trailers worked so efficiently as unloaders that 9,000 tons of grain was discharged in seven days instead of the contracted thirteen and a second cargo was unloaded four days, nine hours and 40 minutes earlier than the undertaking called for.

At Iskenderun, where fourteen Simon trailers are in use, similar successful operations were carried out. Ships are able to come alongside the quays so the trailers are not taken out into the harbour in pontoons.

The Simon Trailers are in three categories. The Pneumatic Machinery unit carries suction/blowing equipment which withdraws grain under suction from one point and discharges it under pressure at another point at a rate of 50 tons an hour. Auxiliary Unit No. 1 cleans and weighs grain at 50 tons per hour. Auxiliary Unit No. 2 weighs grain at the same rate. These units, or any combination of them, are used also to turn over grain stored in temporary huts, and in fact for any operation where grain is to be moved, loaded or unloaded.

Hand and Powered Hydraulic Trucks

New additions to the range of "Sherpa" hydraulic trucks are announced. The Sherpa III is a hand operated stacker designed for the rapid loading or unloading from conveyors, and for general use in the movement of crates, bins, rolls of paper, barrels, etc. The sliding forks move up and down a vertical channel on ball bearings, and power is transmitted to enable the load to be raised or lowered by means of a hydraulic pump which is hand operated. The pump is a self-contained unit with two speeds, one giving rapid lift to light loads or raising the platform when empty, the other for use in raising heavy loads without undue physical effort. The maximum load to 45-in. above the ground is 784 lbs. (356 kg.).

The Sherpa IV, illustrated, is similar in general design to the Sherpa III but it is fitted with a rotary hydraulic pump driven by a 12 volt motor from heavy duty traction batteries. The cacacity of the batteries allows of 60 lifts at full load for each re-charge. The lifting capacity is the same as the Sherpa III, 784 lbs., but the height of lift is greater at 6-ft. 9-in.

The makers are Salisbury Precision Engineering Ltd., 1, Buckingham Palace Mansions, London.

APPOINTMENTS VACANT

SENIOR CIVIL ENGINEER required for Head Office appointment in London. Duties will mainly be connected with the Administration of Overseas Contracts and will involve periodic visits abroad. Applicants should have Contract Experience on Heavy Civil Engineering works including experience of Marine Works. A knowledge of Estimating would be an advantage. The appointment could be delayed for several months to suit a suitable applicant's arrangements. Apply Box No. 173, "The Dock and Harbour Authority," 19 Harcourt Street, London, W.1.

CIVIL ENGINEERING ASSISTANT with experience in dock and harbour design required by consulting engineers in London. A.M.I.C.E. qualifications desirable but not essential. Salary range from £750 upwards based on experience in design generally. Box No. 176, "The Dock and Harbour Authority," 19 Harcourt Street, London, W.1.